Watershed Management Plan

Trail Creek – West Fork

The Unified Government of Athens-Clarke County

December 2010

Department of Transportation and Public Works
120 West Dougherty Street
Athens, GA 30603

Contents

Appendix of Charts and Data

Chapter 1: Introduction

1.1 Purpose of the Trail Creek – West Fork Watershed Management Plan

The Trail Creek – West Fork Watershed Management Plan (WMP) is part of an effort undertaken by Athens-Clarke County Stormwater to address stream health throughout the county. The primary purpose of the Trail Creek – West Fork Watershed Management Plan is to guide County staff, elected officials, community organizations, and the citizenry to protect and where needed restore the beauty and function of the watershed. The plan is intended to be a practical tool with specific recommendations on practices to improve and sustain a healthy, productive environment. Trail Creek is listed on the federal 303(d) list of impaired streams due to fecal coliform contamination and thus part of the management strategies in this plan will seek to address this concern and ultimately allow for removal of the stream from the 303(d) list. This management plan will address most specifically the West Fork of Trail Creek; however, some of the management objectives will be applied to the entirety of Trail Creek.

1.2 Outline of the Trail Creek – West Fork WMP

The plan consists of the following pieces:

- **Chapter 1** provides an introduction including the purpose and an outline of the Trail Creek – West Fork WMP. It also provides a brief description of the watershed including its physical boundaries and landmarks found within the drainage area.
- **Chapter 2** describes briefly the methodology that was used in assessing the watershed's health.
- **Chapter 3** presents the current conditions of the West Fork of Trail Creek including its physical, biological, and water quality conditions. It describes the potential stressors effecting Trail Creek – West Fork.
- **Chapter 4** explains the watershed management plan, a summary of the management needs, the BMPs to be used, estimated load reductions, and implementation schedule and cost assessment, and evaluation methods.
- **Appendix provides** the stream assessment data including physical, biological, and water quality data.

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1.3 Snapshot of Trail Creek

The West Fork of Trail Creek (TCWF), as shown in Figure 1.3.1, lies in the northern portion of Athens-Clarke County, running almost parallel to Highway 29 North. The study section (the West Fork), shown in Figure 1.3.2, begins at the culvert under Collins Industrial Boulevard and continues upstream to the headwaters near Harve Mathis Road. It has a land area of 2.92 square miles and all of this area drains into the North Oconee River.

The West Fork of Trail Creek is a transitional watershed with a mixture of land uses ranging from industrial firms like Baldor/Reliance in the southernmost portion to residential neighborhoods upstream and near the headwaters. Both the Pinewood Estates and Country Corners Mobile Home Parks are located in this watershed, as well as the Timberwood subdivision. Athens Christian School is also located in this watershed. Much of this watershed is undeveloped land. Figure 2.3 provides a bird's-eye view of these locations within TCWF.

Figure 1.3.1: Location of Trail Creek Drainage Basin in Athens-Clarke County

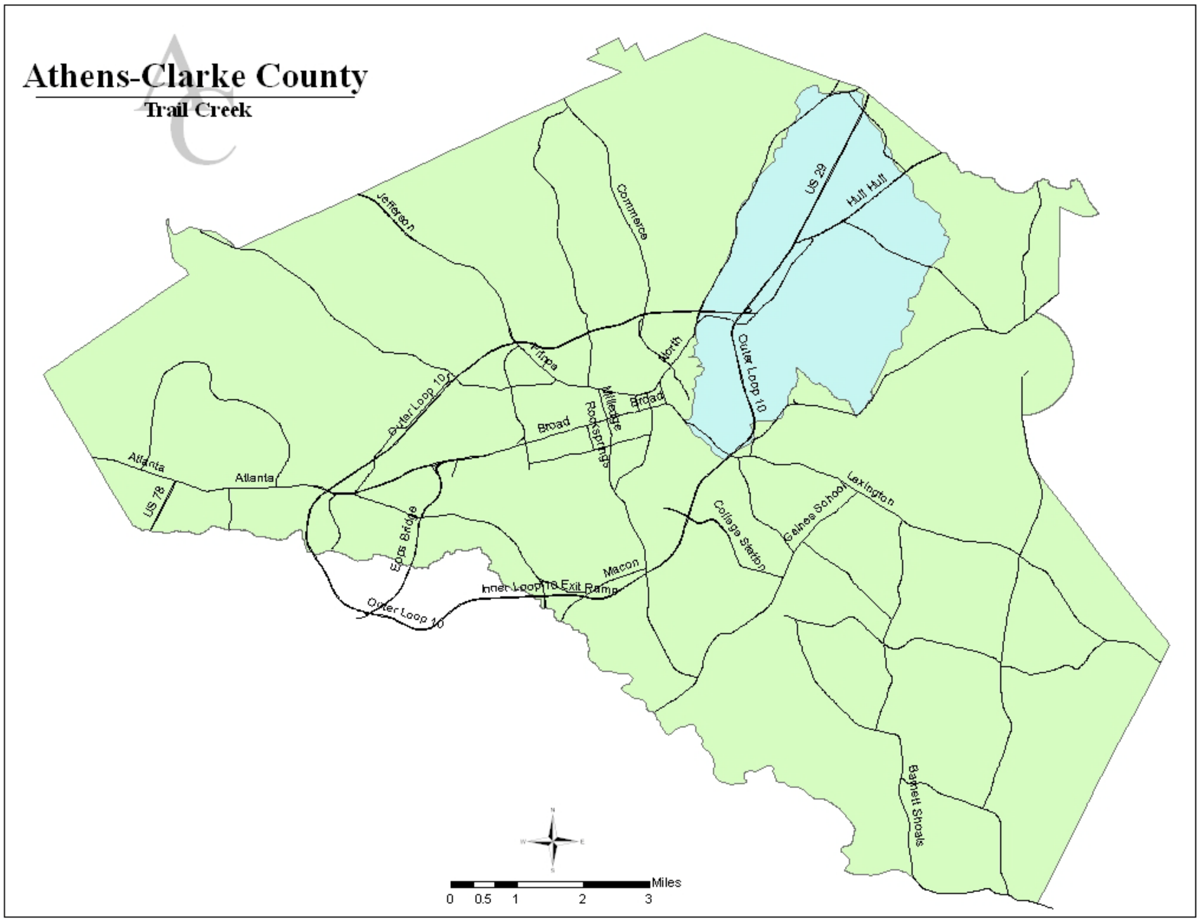


Figure 1.3.2: Close-up of Trail Creek West Fork Drainage Basin

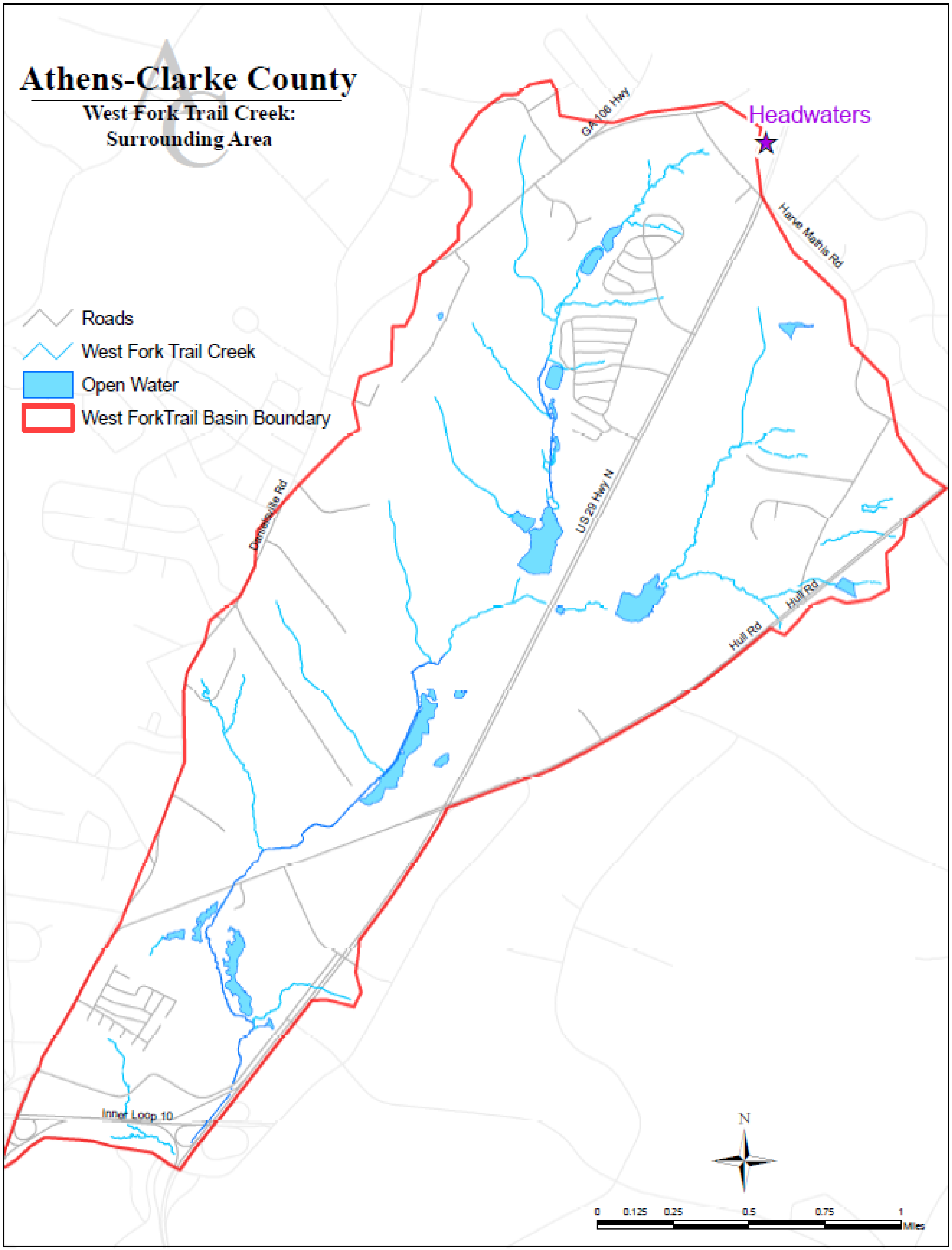
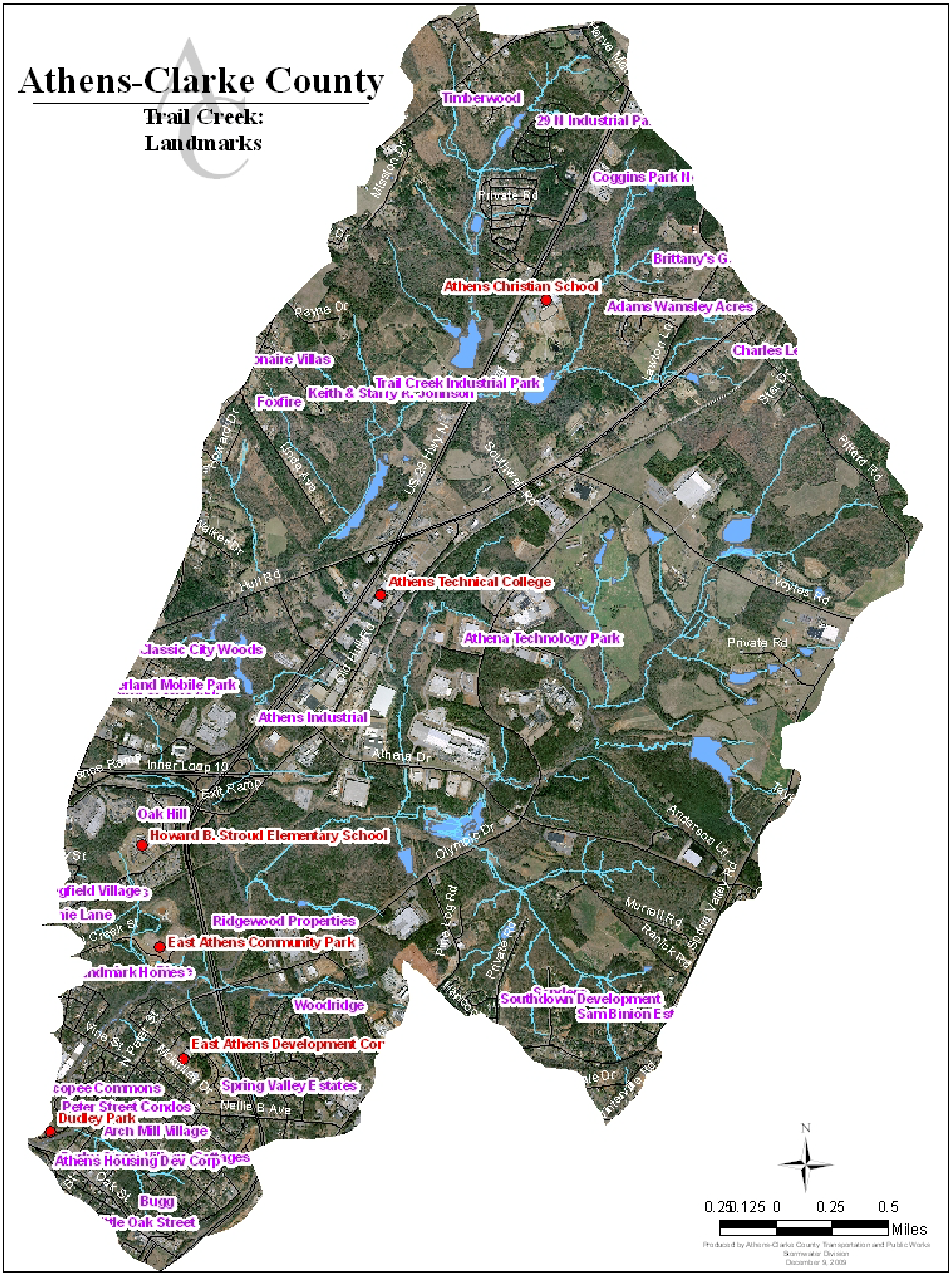


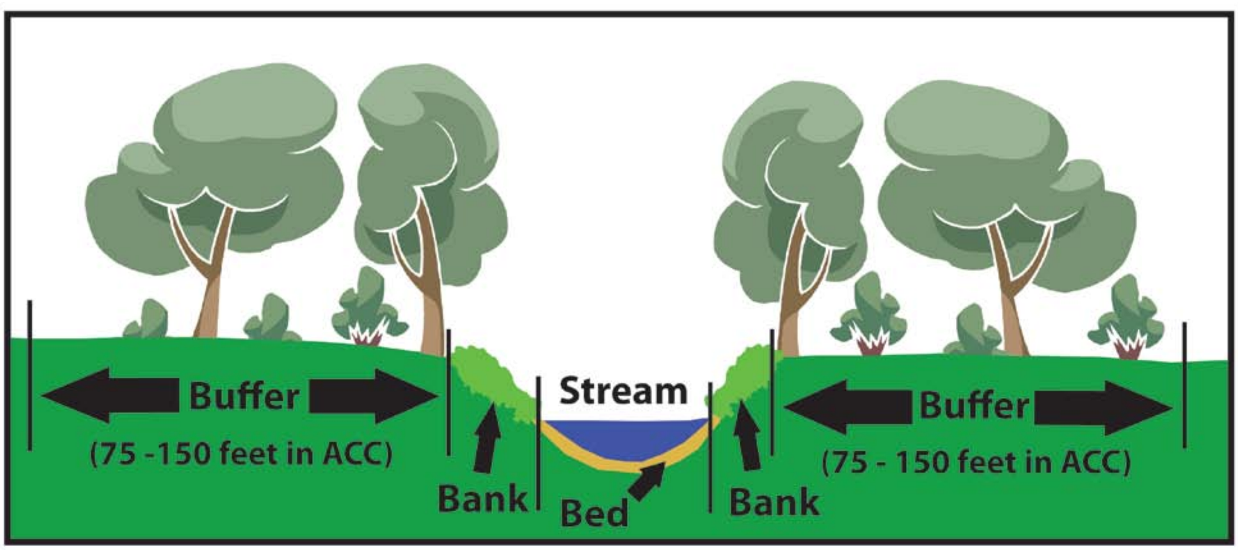
Figure 1.3.3: Landmarks in Trail Creek Drainage Basin



Chapter 2: Methodology

We used three different methods of data collection to gain a full picture of the current health of the West Fork of Trail Creek. Each data collection method will be described in detail, as will our findings and how they compare to “healthy” water quality standards. First, we conducted a stream assessment. ACC Stormwater staff walked West Fork of Trail Creek and its larger tributaries to take physical measurements of the stream bank, stream bed, and stream buffer (Figure 2.1), as well as qualitative measurements of other factors like surrounding land use and stream crossings. A second assessment method was to determine current biological status of the creek. UGA collected macroinvertebrates (tiny aquatic bugs) living in the stream. The type and quantity of macroinvertebrates found is very useful for determining how healthy the stream is through the organisms’ adaptability and survival capabilities. Some macroinvertebrates are more sensitive to pollution and stream bed silting than others, so by assessing what species are present, we can determine whether the stream’s ability to support life has been impacted. The third assessment method was to collect water quality data. We have collected both periodic and long-term water quality data, and we use data collected by GAEPD and local watershed groups that have been sampling and recording water quality data for many years.

Figure 2.1: Cross Section of a Stream



The data from all of these methods is combined to give us a picture of how healthy the West Fork of Trail Creek is at this moment in time, and it guides us towards discovering potential watershed “stressors,” which are sources of pollution and impairment. Let’s look at the data collected through each method and consider what could be stressing the health of the West Fork of Trail Creek.

Chapter 3: Current Conditions in Trail Creek – West Fork

3.1 Physical Stream Assessment

3.1.1 Stream Walk Assessment Method and Scores

Stream walks were conducted in the West Fork of Trail Creek watershed in March of 2009. The stream was divided into sections, and each section is called a “reach.” ACC Stormwater Staff physically walked each reach and conducted an inventory of stream bed, stream bank, and stream buffer condition. (A stream buffer is the vegetated strip of land along either side of the stream.) Figure 3.1.1.1 shows the reaches surveyed in TCWF and the following photos highlight some of the areas in TCWF (Photos 3.1.1.1-3.1.1.2). Reaches are named alphabetically on the main stem of the West Fork of Trail Creek (e.g. TR-1d)

Figure 3.1.1.1: Trail Creek – West Fork Stream Reaches

Photo 3.1.1.1: Stream Assessment of Trail Creek – Taking Bed, Bank, and Buffer Measurements

Trail Creek – West Fork near Linda Avenue

Photo 3.1.1.2: Stream Assessment of Trail Creek – Buffer Completely Removed

Trail Creek – West Fork near Hull Road

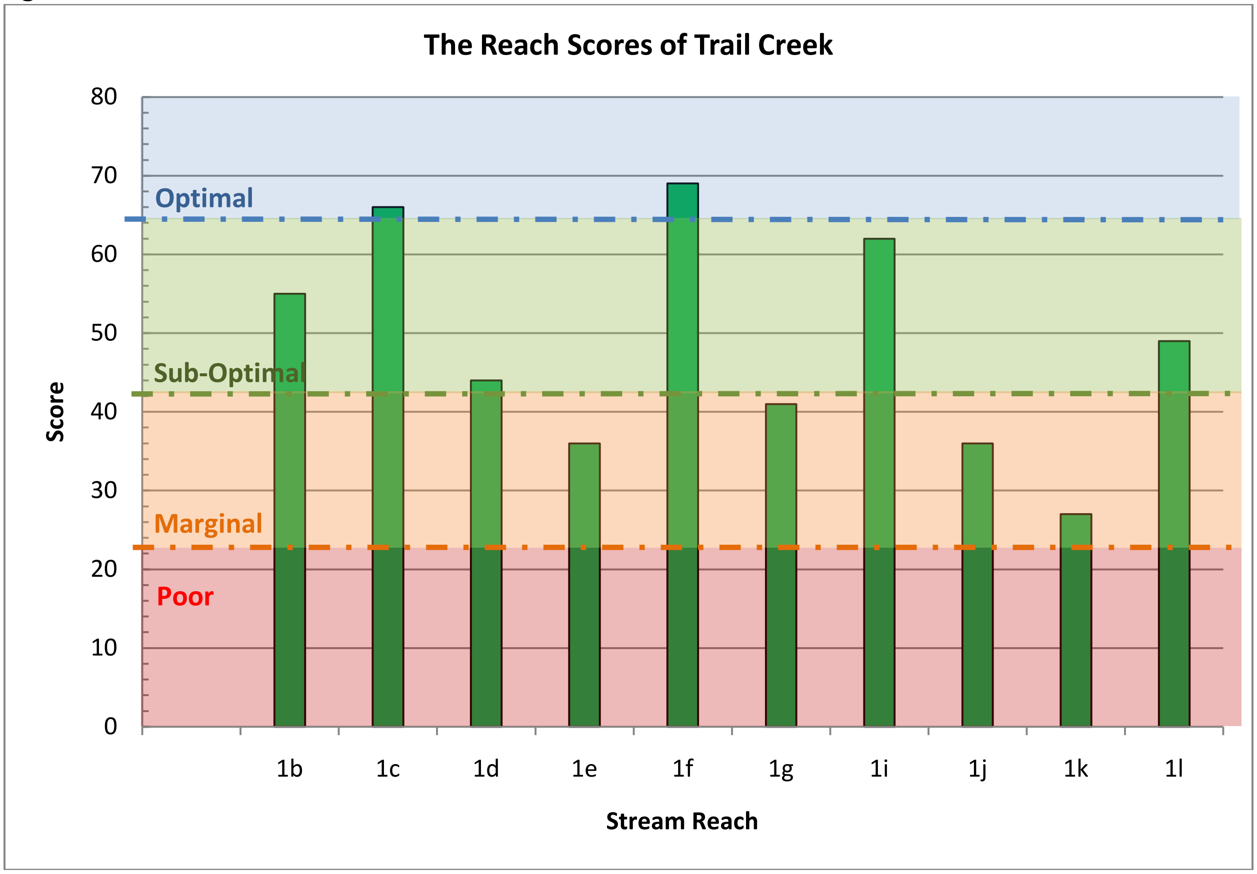
Each reach was rated by the average of the data collected there. The in-stream habitat, vegetated buffer width, bank erosion, and floodplain connection were also evaluated in each reach and assigned a score. Table 3.1.1.1 shows the results of the stream survey. Each category could receive a maximum of 20 points, with vegetated buffer width and bank erosion scores allowed 10 points for each bank. A reach's maximum score is 80. The benchmark set for a "healthy" rating is a score of 63 or above. A score of 63 or greater suggests that a stream has optimal bed, bank, and buffer conditions for a healthy functional stream ecosystem compliant with state and federal regulations. The ranges for the stream assessment scores are: (Poor: 0-23, Marginal: 24-40, Sub-Optimal: 41-63, Optimal: 64 – 80). Figure 3.1.1.2 provides a summary of total reach scores for each stream reach in TCWF. The West Fork of Trail Creek Watershed's overall stream condition is rated as "Sub-Optimal," with an average score of 49 points. Driving this sub-optimal score is impairment of the bed, banks, and buffer of the stream.

Table 3.1.1.1: Reach Scores of Trail Creek – West Fork

Reach	In-Stream Habitat Score	Vegetated Buffer Width Scores		Bank Erosion Score		Floodplain Connection	Total Reach Score	Percent Score
		Left Bank	Right Bank	Left Bank	Right Bank			
1b	15	4	7	9	8	12	**55**	**68.8%**
1c	11	9	10	9	9	18	**66**	**82.5%**
1d	14	3	4	7	7	9	**44**	**55.0%**
1e	11	6	6	4	2	7	**36**	**45.0%**
1f	11	10	10	9	9	20	**69**	**86.3%**
1g	8	7	5	6	6	9	**41**	**51.3%**
1i	9	5	10	9	9	20	**62**	**77.5%**
1j	6	2	10	6	6	6	**36**	**45.0%**
1k	5	4	10	2	3	3	**27**	**33.8%**
1l	10	8	8	7	7	9	**49**	**61.3%**
Averages	**10.0**	**5.8**	**8.0**	**6.8**	**6.6**	**11.3**	**49**	**60.6%**
Percent	**50.0%**	**58.0%**	**80.0%**	**68.0%**	**66.0%**	**56.3%**	**60.6%**	

Table 3.1.1.1 shows the breakdown of the reach assessment scores and the combined scores, as well as the average score of 49.

Figure 3.1.1.2: Reach Scores of Trail Creek – West Fork



Reach TR1f rated the highest (69). This reach was characterized by open water wetlands with low banks and very little erosion and intact buffers. Reach 1k rated the lowest (27). This reach was severely eroded with little to no buffer on the left bank and the bed consisting mostly of sand. This reach also contained to oxidation ponds at Country Corners Mobile Home Park.

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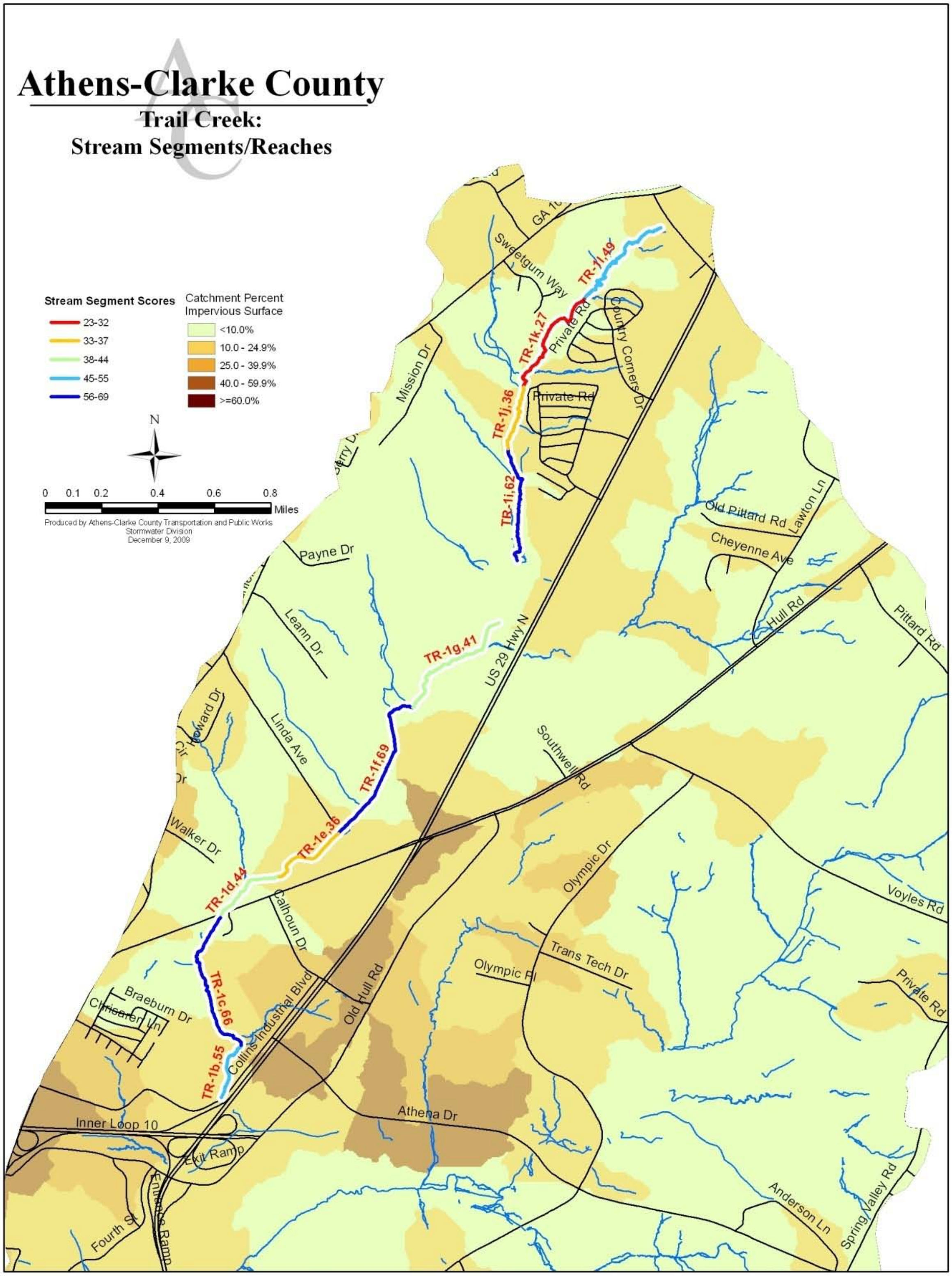
Figure 3.1.1.3: Stream Assessment Scores and Their Reach Locations



3.1.2 Trail Creek – West Fork Stream Bed, Bank, and Buffer

The stream bed of the West Fork of Trail Creek is heavily aggraded and choked with sand and sediment throughout the watershed. There are a number of potential sources for this sand and sediment. Bank erosion is a serious issue in reaches TR-1e and TR-1k, and was less significant but still an issue in four other reaches (TR-1d, TR-1g, TR-1j, and TR-1l). The bank erosion is one likely source of the sand and sediment in the bed of the stream. Other possible source of excess sediment found in streams includes sediment from previous and current agricultural land use and sediment that has runoff from construction or development sites. Compounding the sediment issues on the West Fork of Trail Creek is its relatively flat topography and the numerous beaver dams and the NRCS lake in reach TR-1h of the watershed. These features limit flushing flows that would otherwise clear out sediment. We will evaluate the surrounding area to determine if any of these potential sources have contributed to the sedimentation of the West Fork of Trail Creek. Erosion is harmful to the health of a stream because it impacts the ecosystem. Macroinvertebrates and other wildlife can't survive if their habitat has been eroded and destroyed by sediment. If the creatures at the bottom of the food chain are unable to survive in an aggraded stream, they will never exist in large enough numbers to support wildlife higher up in the food chain like fish, birds, and deer.

A stream buffer is the strip of stream bank closest to a stream that should contain trees, shrubs, and other plants. In Athens, the buffer is protected by state law for 25 feet from the stream, and local ordinance protects the buffer for additional 50 feet for a total protected buffer of 75 feet. This means that it is unlawful to remove trees and other vegetation for 75 feet to either side of the stream. The plants in this protected strip of land surrounding streams provide stream shading for cooler water. The plants also protect stream banks from erosion, filter out pollutants like oil and sediment out of runoff entering the stream, and provide habitat for fish and other wildlife. Development and construction has occurred in Athens for over a century prior to the 75 foot buffer ordinance, and many stream buffers were removed to make way for agriculture, residential homes, commercials areas, and transportation corridors during his period. This development has led to increased impervious surface in TCWF, with approximately 14 percent of the watershed covered with impervious surface. Also contributing to buffer removal is the fact that many current residents are unaware of the importance of a buffer and remove it for aesthetic landscaping purposes. In the West Fork of Trail Creek watershed, the left buffer is frequently impacted by roads (Collins Industrial Blvd. in TR-1b, Hull Rd. in TR-1d and TR-1e), as well as residential use (the home in TR-1e and the Country Corners and Pinewood Estates mobile home parks in TR-1j and TR-1k). The right buffer is largely undisturbed throughout the watershed except for residential use in TR-1d and agricultural use in TR-1g. The most significant disturbance is the Trail Creek Interceptor sewer project with easements following the stream up to the beginning of TR-1l. Residential disturbances include landscaping and lawn maintenance inside the 75 foot protected buffer. Other residential disturbances include trash and debris placement in the buffer zone, which could lead to water quality concerns. This was particularly a concern in reaches TR-1j and TR1k.

The reduction of the buffer also poses a problem for animal migration. Wildlife in urban and suburban watersheds depends on stream corridors to move from habitat to habitat. As buffers diminish wildlife may become stranded in isolated pockets of remaining habitat.

3.1.3 Potential Stressors Effecting Trail Creek's Stream Assessment Scores

Now that we've collected data and compiled what we've seen going on in the West Fork of Trail Creek, we look at the data to try and identify what could be contributing to both the good and bad conditions found in the stream. It is important to remember that we're working with just one data set, which is just one glimpse of stream conditions at one point in time. It can be compared to a doctor trying to diagnose a chronic condition in a patient by only seeing him once; the patient may have been having a good day or a bad day, and we won't know what's really going on until we collect repeated data in the future. This first round of findings does still give us enough information to make some general conclusions about what is impacting the West Fork of Trail Creek and what is not. The greatest piece of evidence we found is the aggraded, silted stream bed in the West Fork of Trail Creek, as evidenced by the poor to marginal habitat scores in half of the ten reaches. Buffer disturbance is also impacting the watershed, particularly on the left bank.

3.2 Biological Stream Assessment

3.2.1 How Macroinvertebrates Are Indicators of Stream Health

As mentioned earlier, macroinvertebrates are small bugs that can be seen with the human eye that live in the beds of streams. Since different species of macroinvertebrates are more sensitive to pollution and other impairments than others, the number and diversity of macroinvertebrates that are found in a stream can tell us a lot about water quality and stream health.

Photo 3.2.1.1: Macroinvertebrates

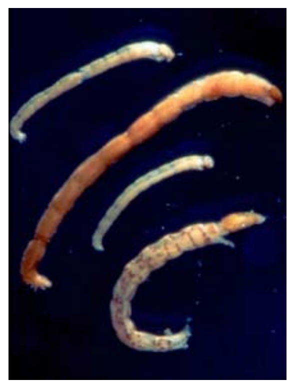
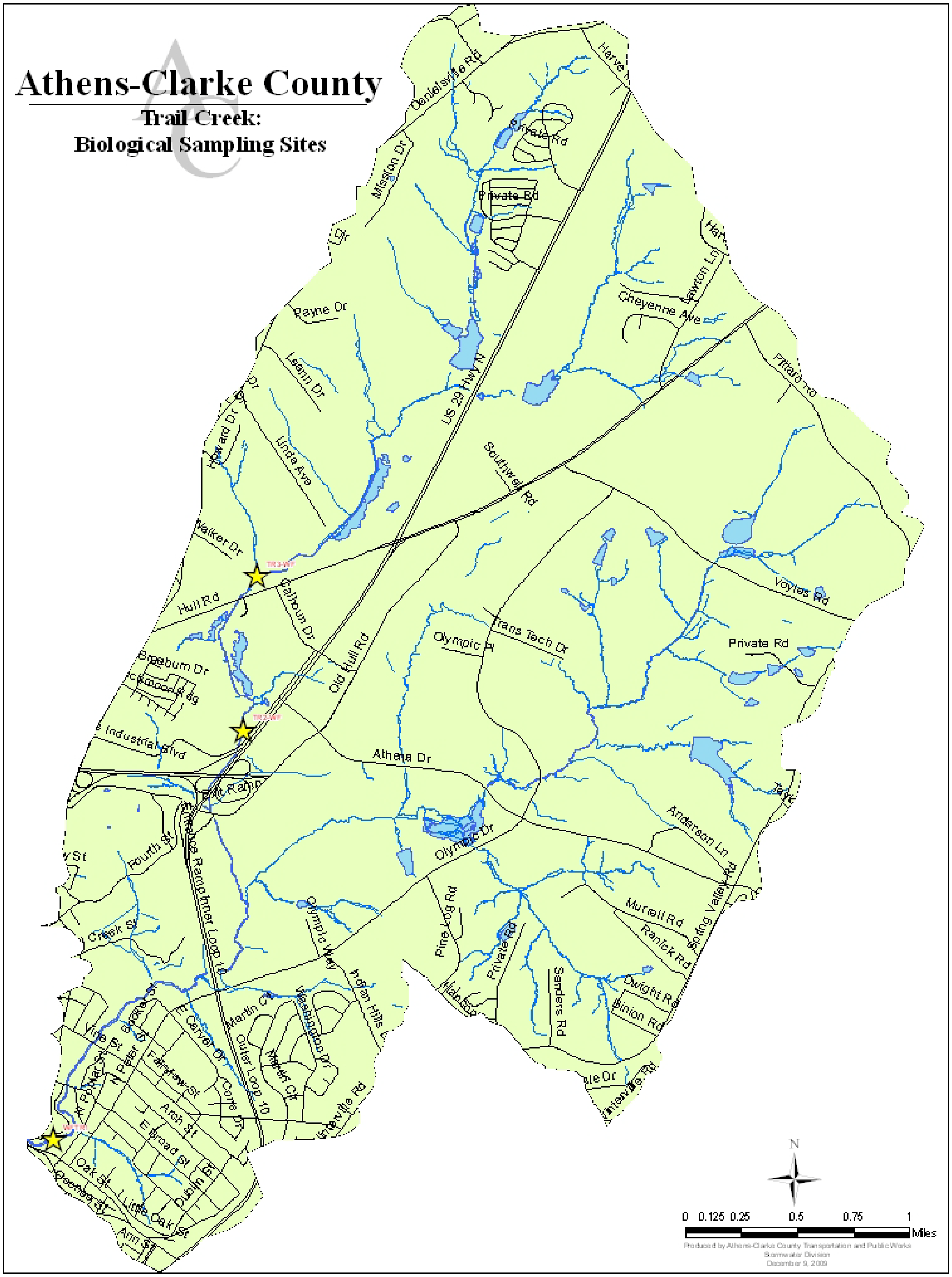



Photo 3.2.1.2: Macroinvertebrate Sampling

3.2.2 Macroinvertebrate Collection and Scoring Method

Macroinvertebrates were collected at three stream sites, shown in Figure 3.2.2.1, in Trail Creek in March of both 2008 and 2009 using a rapid assessment protocol, which is a time saving but scientifically sound way of collecting macoinvertebrate samples (as seen in Photo 3.2.1.2). The results from the sampling sites were scored using the *Save Our Streams Program* of the Izaak Walton League of America, which is based on the presence or absence of “sensitive,” “somewhat sensitive,” and “tolerant” types of macroinvertebrates. Numerical scores were used to indicate water quality (excellent > 22, good = 17-21, fair = 11-16, poor < 11).

Figure 3.2.2.1: Trail Creek Biological Sampling Site Locations



3.2.3 Biological Score Results for Trail Creek

Table 3.2.3.1 below lists the biological score for each sampling site. Please refer to the map to see where each sampling site is located in the Trail Creek drainage basin. It is important to note that site TR1 is on the main stem of Trail Creek downstream of the confluence between the east and west forks.

Table 3.2.3.1 Macroinvertebrate Scores

Sample Site	Score	Rating
TR1	6	poor
TR2-WF	22	excellent
TR3-WF	16	fair

So, Sample Site TR1's score falls in the "poor" range, Site TR2-WF's score falls into the "excellent" range, and Site TR3-WF's score falls into the "fair" range.

Table 3.2.3.2 below lists the mean, median, minimum and maximum bed substrate size for each sampling site. In July 2009, 100 stream bed particles were measured at each sampling site from a variety of bed habitats using the Woman Pebble Count (1954). Many macroinvertebrate taxa live in riffle areas created by water moving over the stream bed material while others live in sandy pools. A wide range in bed sediment sizes provides a variety of habitat for different aquatic organisms that have different life history characteristics. TR2-WF and TR3-WF have a larger mean, median and greater range of pebble sizes than TR1, indicating better invertebrate habitat.

Table 3.2.3.2 Pebble Counts

Sample Site	Mean (mm)	Median (mm)	Min. (mm)	Max. (mm)
TR1	7.4	6	<1	29
TR2-WF	79.8	21	<1	>2000
TR3-WF	50	97.1	<1	>2000

3.2.4 Potential Stressors Effecting Trail Creek's Biological Scores

Low amounts and decreased diversity of aquatic macroinvertebrates in urban streams are caused by the alteration of all aspects of stream habitat. During stream walks in the West Fork of Trail Creek (see section 4), the stream bed was found to heavily sedimented and aggraded in many reaches. The deposition of fine sediments fills in natural rocky riffle habitat where many macroinvertebrates live. In the West Fork Trail Creek watershed, TR2-WF had a high mean, median and variability in bed sediment size (Table 3.2.3.2), which corresponded to a "excellent" score on the index we used to assess macroinvertebrate diversity (Table 5.1) This reach (TR-1d; Table 3.1.1.1) had one of the highest scores in the reach assessment (55/80; Table 3.1.1.1) and little bank erosion was observed.

The substrate in TR3-WF had lower mean, median and variability in bed sediment size than TR2-WF and lower invertebrate scores, signaling that substrate is one likely driver of reduced macroinvertebrate diversity. Scores from the reach assessment (44/80; Table 3.1.1.1) indicate that this area has sub-optimal habitat with reduced vegetated buffers and moderate erosion on either side of the stream reach. Reduced stream buffers decrease shading resulting in increased stream temperatures. This may inhibit some macroinvertebrate taxa that are sensitive to high water temperatures. Benchmarks for temperature were set at 30°C (Table 3.3.3.1), and no temperatures exceeded this during the sampling period in Trail Creek. Thermal pollution is not a likely source of decreased macroinvertebrate scores. A reduction in vegetated buffers may, more importantly, decrease the amount of leaves and wood being delivered to the stream, important food and habitat sources for macroinvertebrates.

The visual stream survey was not conducted on the main stem of Trail Creek; therefore we cannot relate those data to the invertebrate data as we did in West Fork Trail Creek. Still, we observed reduced stream buffer, eroded banks and low variability in bed sediment size (Table 3.2.3.2), which corresponded to a “Poor” score on the macroinvertebrate index we used (Table 3.2.3.1).

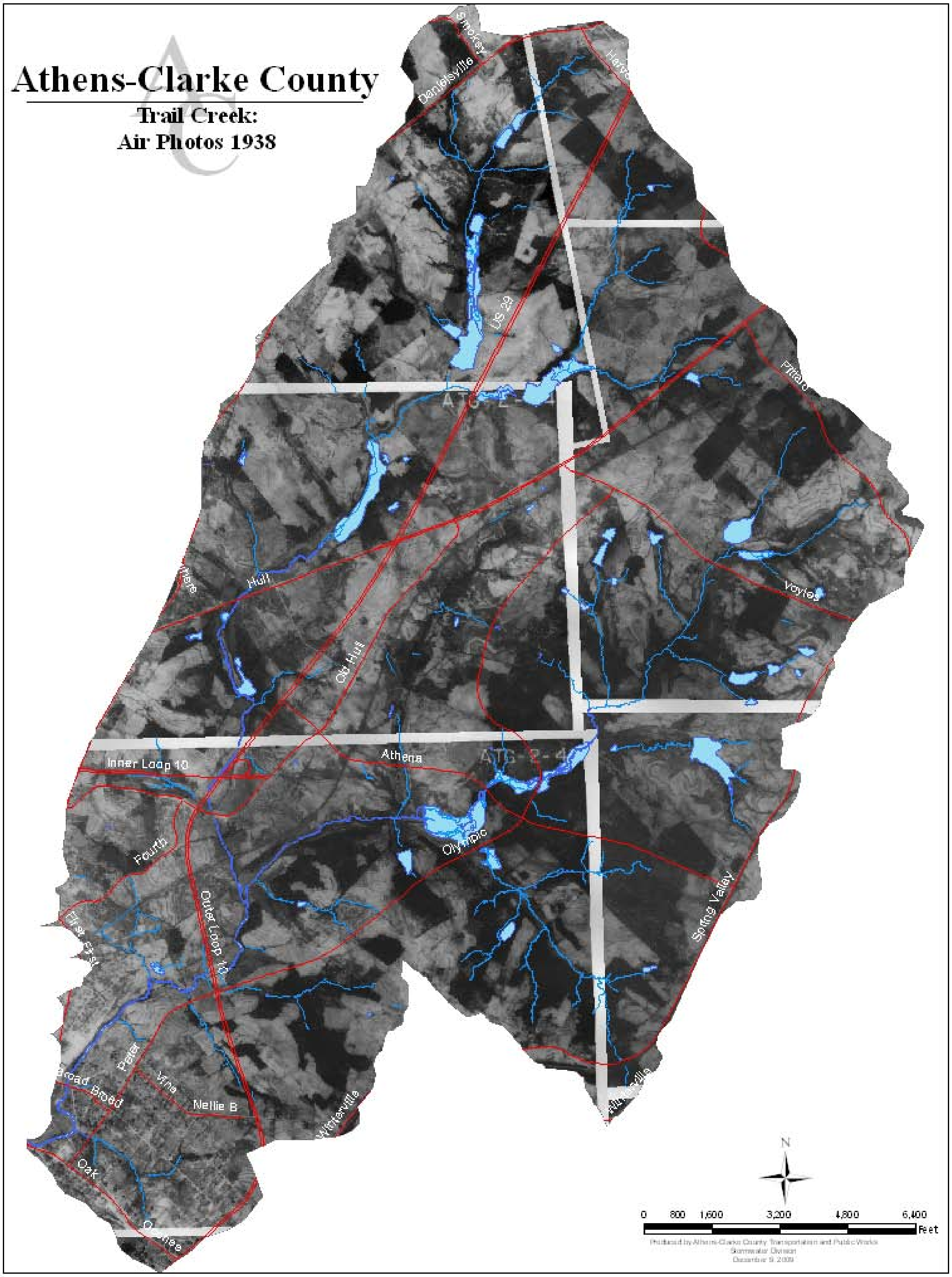
In Photo 3.2.4.1 cobble is present in the bed and undercut banks provide habitat for macroinvertebrates. In Photo 3.2.4.2, the bed is choked by sand and the heavily eroded banks provide no habitat.

Photo 3.2.4.1: Good Stream Habitat

Photo 3.2.4.2: Poor Stream Habitat

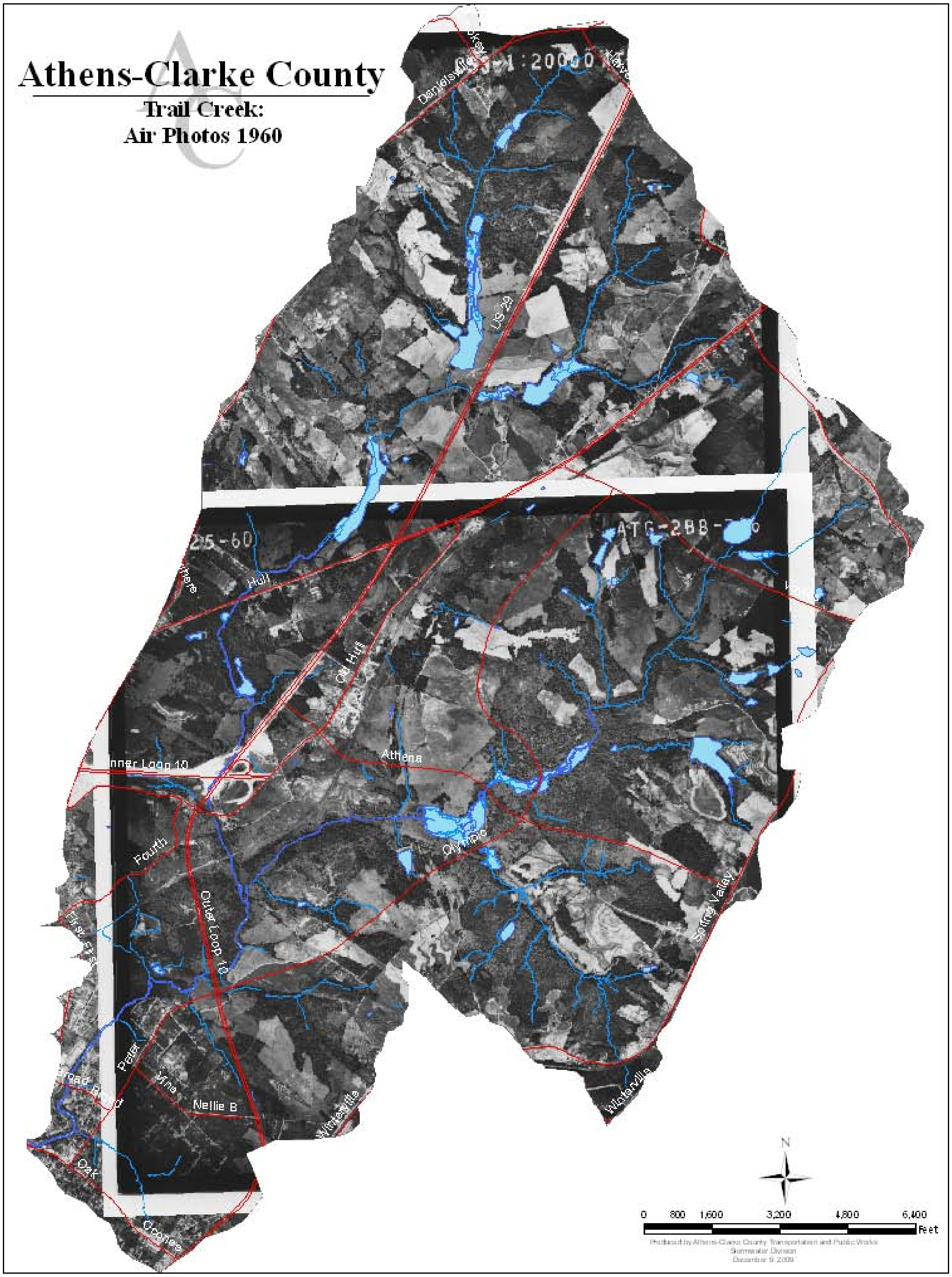
Since excess sediment in the stream is the main cause of the stream bed aggradation, it's important to determine where that extra sediment might be coming from. When considering the impacts of sediment, we need to look not only at what is happening in the West Fork of Trail Creek right now, but also at what went on in the West Fork of Trail Creek basin regarding land use in the past. Review of historical aerial photography shows that the Trail Creek basin area was primarily used for agriculture as far back as the early 1800's up until the 1950's. Figure 3.2.4.1 shows a map of the area in 1938 with little development, but mostly agriculture throughout the watershed. Maps of this area from the 1960s, Figure 5.3 shows some development in the southern sections of the watershed. By the 1980's residential areas continued to develop in the southern section, with some industrial development also in the area (Figure 5.4). The effects of past agricultural use on the land often continue to impact local streams even 50 to 100 years after agricultural practices have been abandoned, manifesting as physical and chemical problems in streams (MacTammany, 2004). Refer to the following historical maps to see how land use has changed over time in West Fork of Trail Creek.

Figure 3.2.4.1: Trail Creek 1938



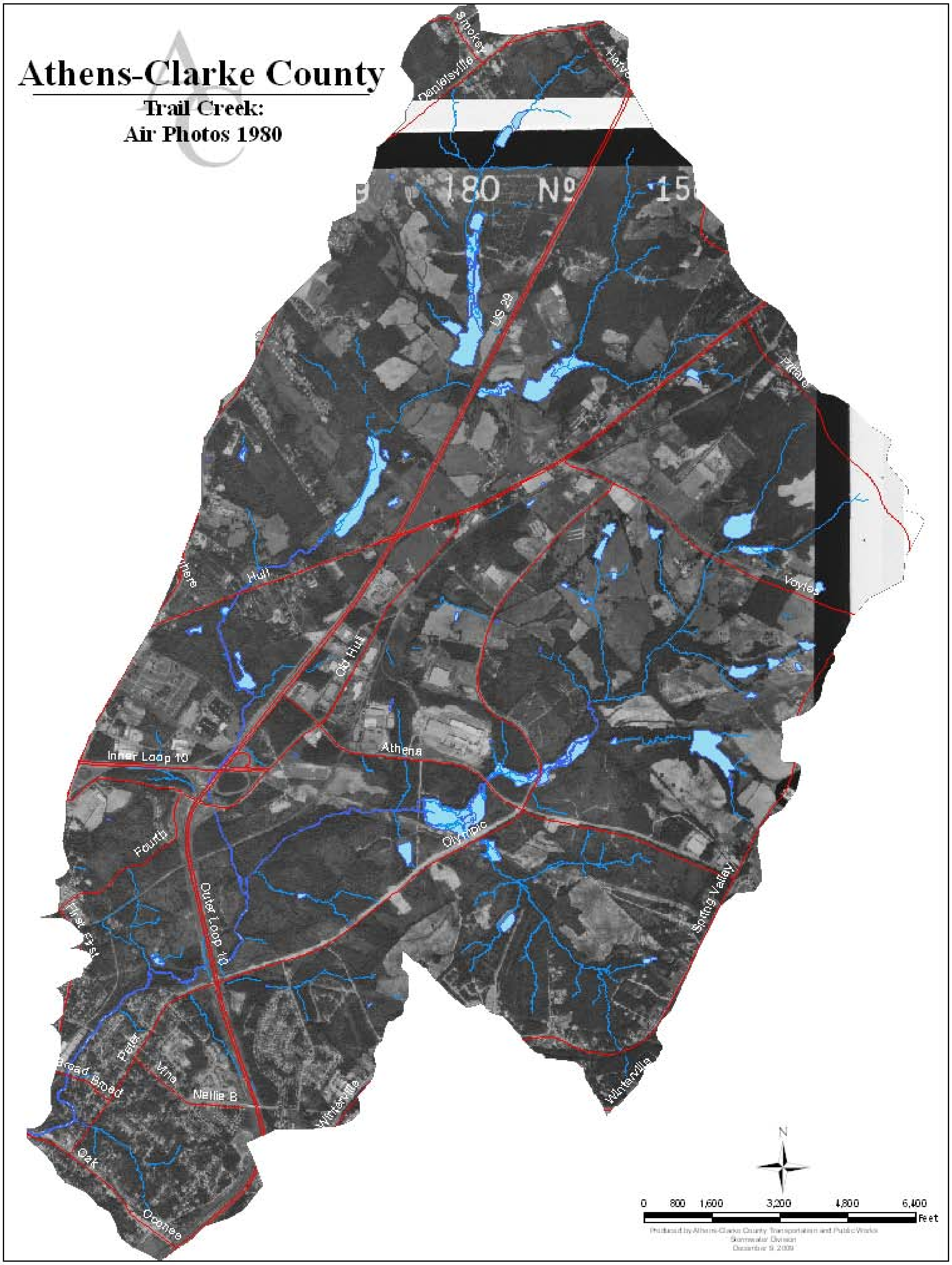
Trail Creek in 1938. Residential development is evident in the southernmost portions (along main branch), but overall it is mostly agricultural and forested land.

Figure 3.2.4.2: Trail Creek 1960



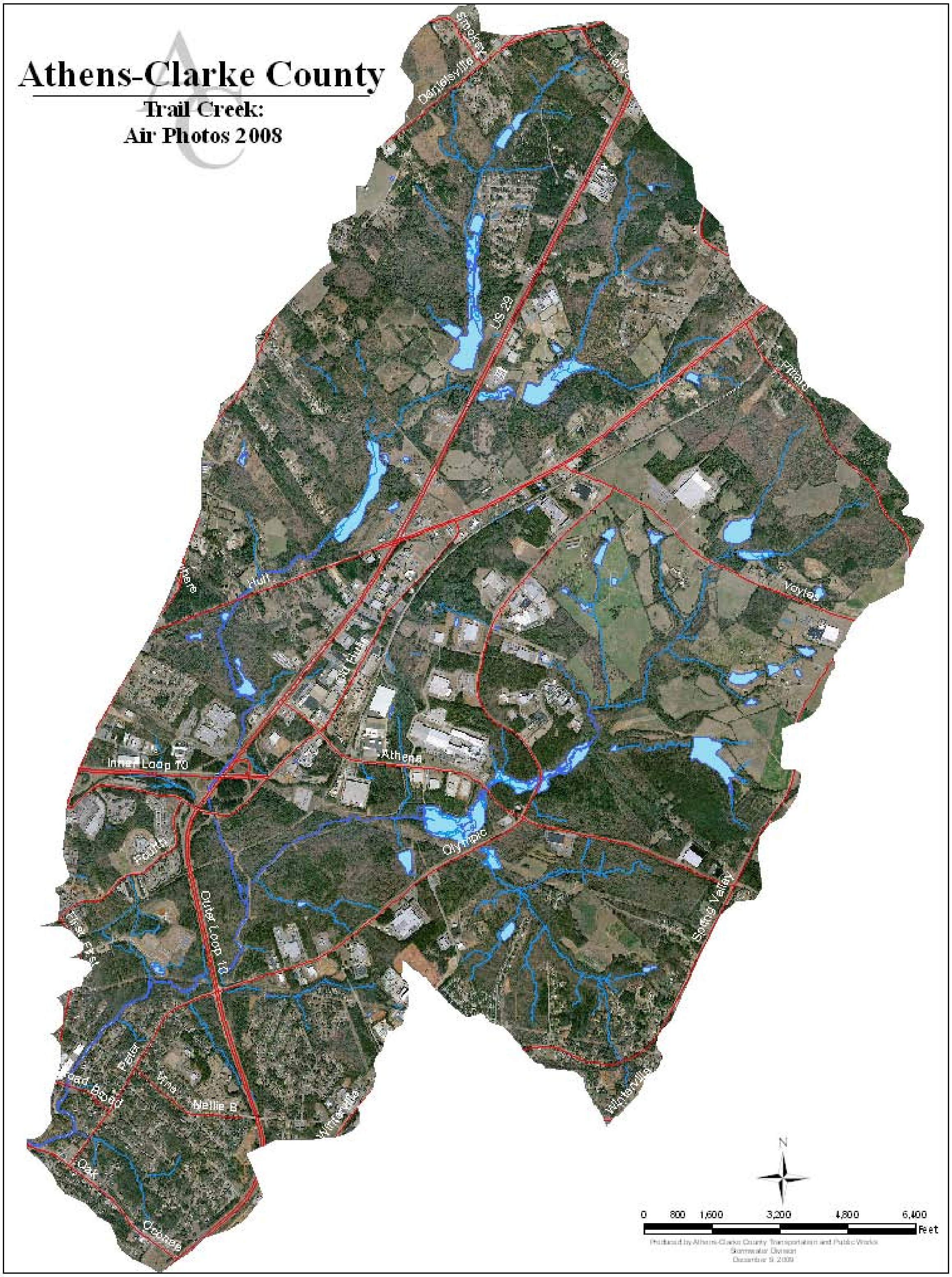
Trail Creek in 1960. Development is increasing in the southern portions of the watershed, but the northernmost portions of the watershed remains agricultural and forested land.

Figure 3.2.4.3: Trail Creek: 1980



Trail Creek in 1980. Development has continued throughout the watershed with industrial development now evident in the middle portion.

Figure 3.2.4.4: Trail Creek in 2008



Trail Creek in 2008. A large portion of the watershed is now developed with residential development in the southern and most northern portions and commercial and industrial development in between.

Agriculture affects streams in several ways. First, clear cutting trees to make way for cropland destroyed much of the stream buffers in the Trail Creek area. Removal of stream buffers and land clearing can increase runoff and sediment entering the stream systems. The wood debris and leaves produced by trees falls into streams and provides food for macroinvertebrates. As trees disappear so does the primary food source of macroinvertebrates. Agricultural periods can also increase the amount of nutrients present in the stream system. These nutrients can come from fertilizers put on crops that get washed into a stream during a rainstorm, or the nutrients can come from manure, so if livestock are raised on the farmland nutrient s and bacteria may wash into the stream. Finally, sediment may leave farmland via runoff as well. Sediment that enters a waterway from agriculture may take a long time to move out of the stream since the sediment is suspended in the water when it is stirred up, but settles and deposits at different points in the stream network. This process of transportation and deposition must be repeated many times before the sediment finally makes its way to a larger river.

The history of stormwater controls also has an impact on the amount of suitable macroinvertebrate habitat found in streams. Prior to the early 1980s, there were no stormwater design requirements for new development projects. This means that stormwater controls like detention ponds, filtration systems, catch basins, and underground piped systems that collect, filter, and slow down runoff were never installed. Even now, there are very few of these types of best management practices (BMPs) in place in TCWF. Runoff leaving sites without stormwater controls often enters streams at a higher velocity and volume that it does when it leaves a site that does employ stormwater controls. The increased velocity can cause stream bank scouring and erosion when the runoff enters a stream, and it also flushes the stream system of suitable habitat as well as macroinvertebrates.

In Trail Creek our data tells us that water temperatures are in the normal range, but that buffer damage and sedimentation has reduced macroinvertebrate habitat along five of the ten reaches, particularly those upstream (TR-1g, TR-1i, TR-1j, TR-1k, TR-1l). However, the other five reaches scored in the sub-optimal range and likely led to one biological monitoring site scoring excellent. Sampling results also indicate that sediment is sometimes suspended in the water of Trail Creek at levels that make it difficult for macroinvertebrates to survive. (See Section II.1: *Water Quality Data* in the Appendix.)

The University of Georgia has also collected algae samples from the biological monitoring sites. In Trail Creek an above average amount of algae was noted. Also, a seasonal pattern of algal growth was also identified; indicating light might be a factor in algal growth and highlighting the importance of buffers. Above average algae growth in streams is an indicator of increased nutrients from sources such as fertilizer, wastewater, and atmospheric deposition, as well as current problems with sewer spills. Understanding how nutrient concentrations stimulate algal growth in Trail Creek is important in managing the nutrient inputs and further studies are needed.

3.3 Water Quality Data

3.3.1 Why Sample?

Water quality data are used to characterize waters, identify trends over time, identify emerging problems, determine whether pollution control programs are working, help direct pollution control efforts to where they are most needed, and respond to emergencies such as floods and spills (EPA, *Monitoring and Assessing Water Quality*). We collected water samples from each of the pilot basins along with a reference watershed, Bear Creek. Water quality sample results are compared to a set of water quality benchmarks created by combining both regulatory standards (*Georgia Water Quality*

Standards) and previous research. These benchmarks represent measures of healthy streams. Collecting and testing water quality samples over time gives us a better picture of what pollutants might be traversing our local waterways like Trail Creek.

3.3.2 Three Water Quality Sampling Methods

Three sampling methods are used to collect water quality data in this project. First, monthly sampling was conducted at three sampling sites in the watershed. These grab samples cover a wide range of parameters that indicate water quality. We can compare variation in monthly water quality data with stream walks, biological data, and other watershed activities that have happened during the same timeframe to identify potential sources of pollution. Another method we use is in-situ water sampling using data collection units called Datasondes. These data collection units are left in-stream to give us continuous trend-identifying water quality data as indicated by measures of pH, dissolve oxygen, conductivity, turbidity, and temperature. The continuous data is used to identify changes to basic stream chemistry over time and seasonally. The data can also identify significant changes to stream chemistry over time. The third method is using wet weather sampling devices. These devices are also left in stream, but they are only triggered by rainfall. They automatically take samples at regular intervals after a rainfall event so that we can understand the quantity and type of pollutants that enter a stream after it rains, and how that pollution relates to nearby land-use. Wet weather samplers have not been deployed on Trail Creek at this time.

Monthly Sampling

Monthly water quality sampling was collected by the grab method, meaning samples were collected from all sample sites at the same time. This method is in compliance with our EPA-approved Quality Assurance Protection Plan (QAPP) that ensures accuracy of results by standardizing our sampling procedures. The criteria sampled were water temperature, pH, dissolved oxygen, conductivity, fecal coliform bacteria, total suspended solids, biochemical oxygen demand, turbidity, total organic carbon, nutrients, and metals. Each criterion is an indicator for a potential type of water pollution. Analysis is conducted by several different labs including the Athens-Clarke County Public Utilities Water Treatment Lab and three University of Georgia Labs: The Center for Applied Isotope Studies; The Soil, Plant, and Water Lab; and the Analytical Chemistry Laboratory. The labs follow methods taken from the *Standard Methods for the Examination of Water and Wastewater* as developed by the American Public Health Association, the American Water Works Association, and the Water Environment Federation (APHA). Figure 3.3.2.1 includes the water quality sampling sites in Trail Creek. Sample data is provided in Appendix Section II.1.

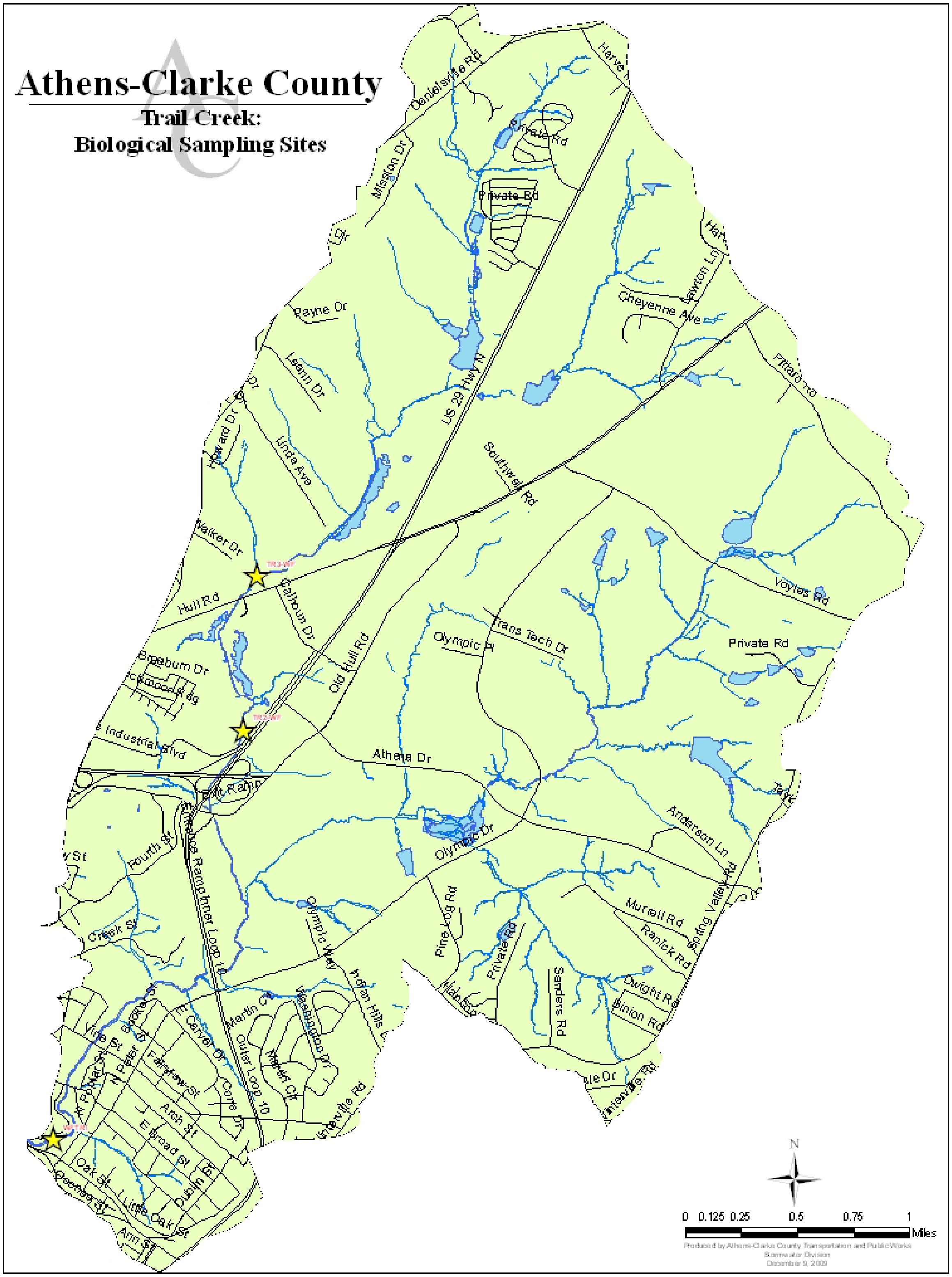
In-Situ Water Sampling Using Datasondes

The Datasonde has multiple probes that sense the following water quality indicators: dissolved oxygen, pH, temperature, conductivity and turbidity. It is able to store these measurements until a staff member retrieves the unit from the stream and downloads the data. Datasondes make it possible for us to collect real-time continuous data without having to be present. The Datasondes are calibrated and checked after each data collection before being returned to the stream. Sample data is provided in Appendix Section II.3.

Wet Weather Sampling Using Isco Samplers

Similar to Datasondes, Isco samplers allow us to collect stream samples without having to be present in a stream at the sample moment. The Isco sampler is triggered by rainfall and it draws and stores water samples at regular intervals from the stream. This unit does not analyze the water in field; staff members collect the water samples from the unit and take them to their respective labs for analysis. Looking at water quality in regular time intervals after a rainstorm has occurred tells us the quantity and types of pollution moving through the stream during rain events. The type of pollution found can also indicate its origins, which is very helpful information for designing a watershed management plan that intends to reduce pollution in a watershed as much as possible. The results are analyzed with consideration to the surrounding land use of the sampling sites as well. For example, the wet weather sampling results may indicate high nutrient content that could be associated with fertilizer use. If this is the case in a residential area, we may look to homeowners' fertilizing practices. There are no wet weather samplers deployed on Trail Creek at this time, modeling was conducted in order to determine the expected pollutant loading rates in Trail Creek.

Figure 3.3.2.1: Trail Creek Water Quality Sampling Sites



3.3.3 Water Quality Data for Trail Creek

Georgia's water quality standards are set by the State of Georgia Environmental Protection Division (GAEPD). According to the State, the "healthy" range for a number of criteria depends on the designated use of the stream as made by GAEPD. A stream designated for fishing has a higher water quality criterion than one that is just used for outdoor recreation since the fish might be consumed by people. For this project, water quality health is determined using a set of benchmarks defined both by the state water quality standards and previous research. Previous research included a literature review focused on instream, baseflow measurements within the Georgia piedmont. Table 3.3.3.1 shows the benchmarks for all water quality data used in this project, with the bolded benchmarks having regulatory implications. Trail Creek is designated as recreational use stream. Based on available water quality data, the primary areas of concern related to the benchmarks in Table 3.3.3.1 for Trail Creek are Fecal Coliform, Nutrients, and TSS. To view all sampling results, refer to the chart *Water Quality Data* in the Appendix where samples scoring outside of the designated "healthy" range are highlighted yellow. These results will be further discussed here.

Table 3.3.3.1: Water Quality Benchmarks and Monthly Average Values

Parameter	Benchmark*	TR1	TR2-WF	TR3-WF
Temperature	**< 30 deg C**	14.40	14.52	13.77
pH	**6.0 to 8.5**	7.38	6.97	6.65
Turbidity	3 - 30 NTU	17.67	18.26	20.99
Dissolved Oxygen (DO)	**> 5 mg/L**	8.29	8.10	8.51
Conductivity	0 - 1.5 mS/cm	1.48	1.35	1.03
Fecal Coliform	**< 500 col**	683	252	430
Total Suspended Solids (TSS)	< 13 mg/L	13	13	16
BOD	1 - 3 mg/L	1.40	1.36	1.70
TOC	> 5 mg/L	9.23	8.06	6.82
NO3	0.2 – 0.4 mg/L	0.38	0.33	0.41
NH3	0.01 – 1 mg/L	0.09	0.15	0.16
TN	0.7 – 1.2 mg/L	0.74	0.79	0.84
PO4	0.002 – 0.1 mg/L	0.0076	0.0084	0.0077
TP	0.06 – 0.24 mg/L	0.038	0.035	0.038
Copper	**< 5 µg/L**	4.21	5.62	7.28
Zinc	**<65 µg/L**	81.43	59.80	58.70

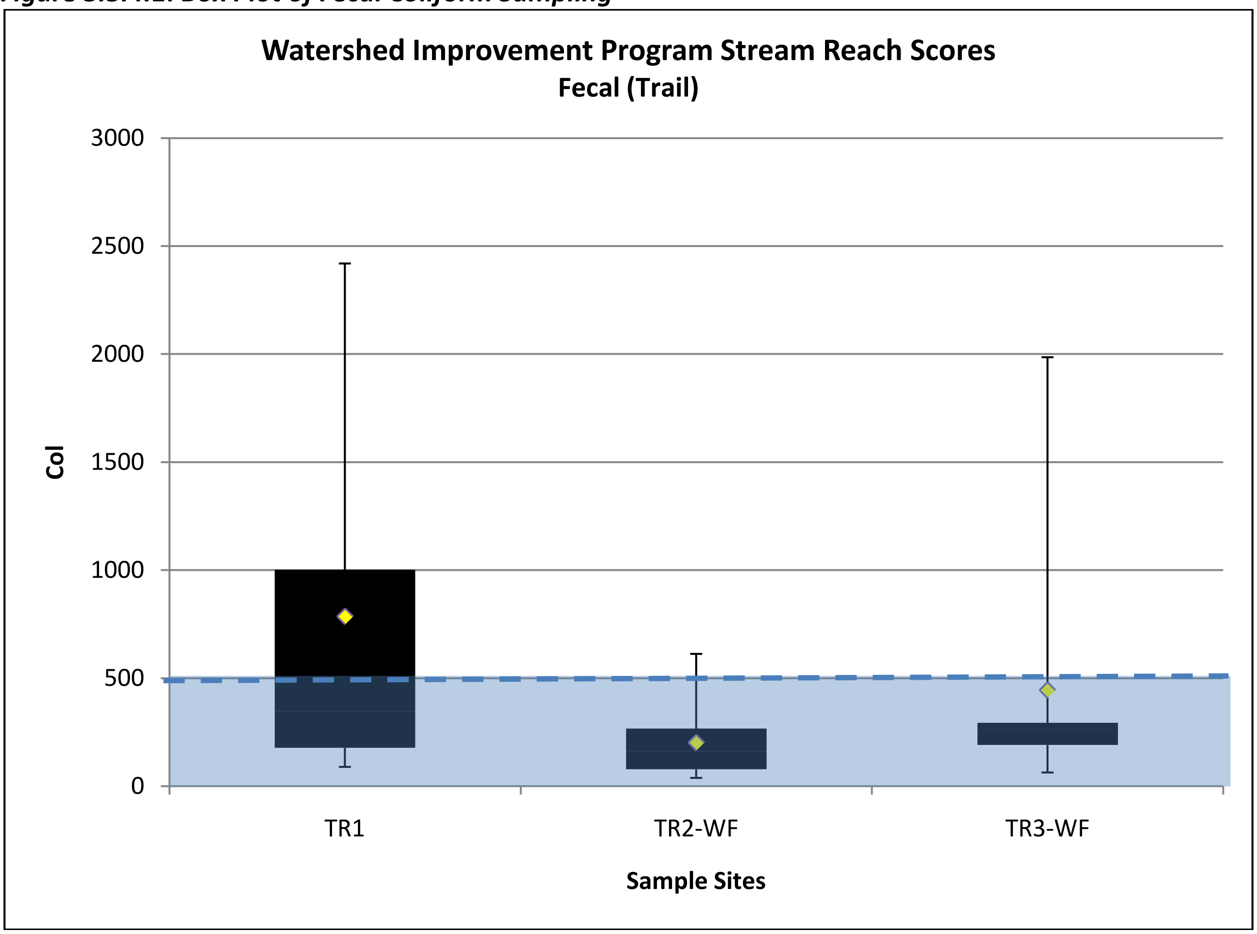
Bold = Regulatory standard as defined by Georgia State Water Quality Standards (2009). Non-bold items are parameters that were also measured. Values in exceedance are not a violation of water quality standards, but indicate poor stream health.
*Benchmarks are for streams under normal flow conditions.

3.3.4 Potential Stressors Effecting Trail's Water Quality Scores

If a water quality indicator is not within the acceptable range as designated by GAEPD, this means there has been a standards violation. When it exceeds a benchmark, not a standard, this means the parameter is indicating poor stream health. When we find a violation we look at what might be causing a water quality criterion to be out of range. In Trail Creek, several fecal coliform bacteria, total suspended solids, and nutrient scores were out of acceptable range, but no identifiable trends were noticed.

In our monthly sampling, samples with fecal coliform results exceeding our benchmarks occurred twelve (12) times spread across the three sampling sites. Our data was not consistent across the watershed and did not indicate any identifiable trends. Particularly significant is that most of the results exceeding the benchmark for fecal coliform occurred at sample site TR1, which is on the main stem and much further downstream from the other sampling sites. This could mean there is a source on the East Fork or in the main stem. The fluctuation across the sampling period does not suggest there is an ongoing source of fecal coliform contamination. Figure 3.3.4.1 contains box plots of all fecal coliform showing that the greatest concern lies at site TR1.

Figure 3.3.4.1: Box Plot of Fecal Coliform Sampling



Fecal coliform can come from leaking septic systems or sewer lines, businesses that have permits to put water back into a stream after an industrial process, and from animal waste. Between November 1997 and December 2008 there were 12 sewer spills within the Trail Creek Basin reported by the Athens-Clarke County Public Utilities Department with all of them occurring on the East Fork, only upstream of sampling site TR1. One of these spills occurred during the study period (July 2008) and is highlighted on the map of all spills in Figure 3.3.4.2. All of these leaks were repaired. Being in a more rural part of

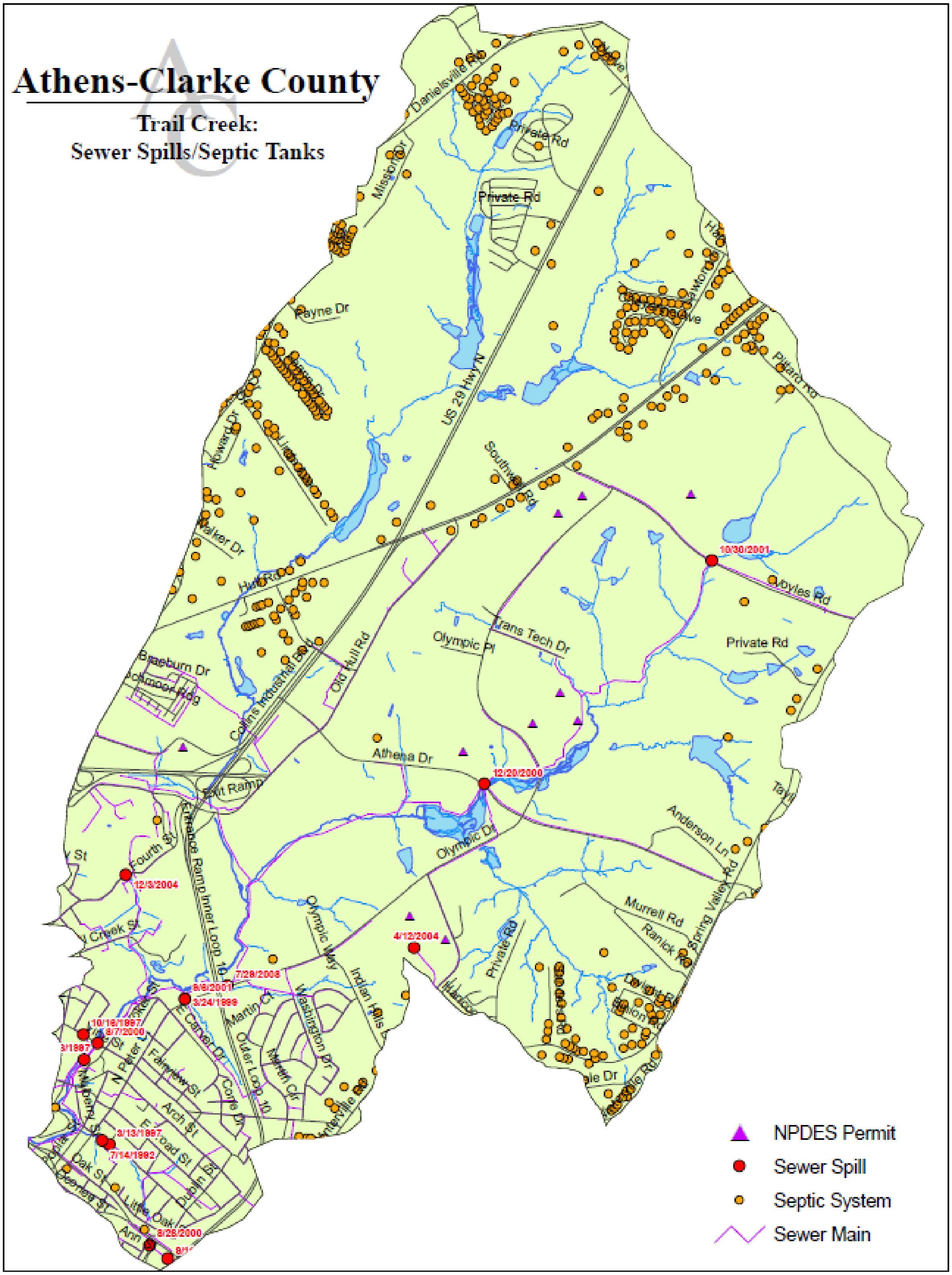
Athens-Clarke County, Trail Creek also has many septic tanks. An aerial infrared survey conducted in February 2008 did not reveal any septic tank concerns, but this cannot rule these out as a potential source of fecal coliform contamination.

Another important potential source of fecal coliform are the oxidation ponds located at the Pinewood Estates and Country Corners Mobile Home Parks. These ponds are regulated by GAEPD and monthly sampling is conducted by the property owners, who must then submit any bacteria counts exceeding state standards to GAEPD. ACC Stormwater has received complaints and concerns about the ponds and conducted sampling in the stream near the ponds as well. One sample of the effluent from the pond at Country Corners had a fecal count of 3589 col/100 mL, but further sampling did not exceed standards. GAEPD was notified of our concern, but no further action was taken by GAEPD.

Agricultural land use may also contribute fecal coliform to the stream. Cattle farming was observed in reach TR-1l and there were no barriers to prevent the cows from entering and crossing the stream. In fact, manure was noted on the banks and in the stream. Another common agricultural practice is the use of manure as fertilizer. In rain events, this manure can runoff into the stream and may contribute to fecal coliform bacteria concerns.

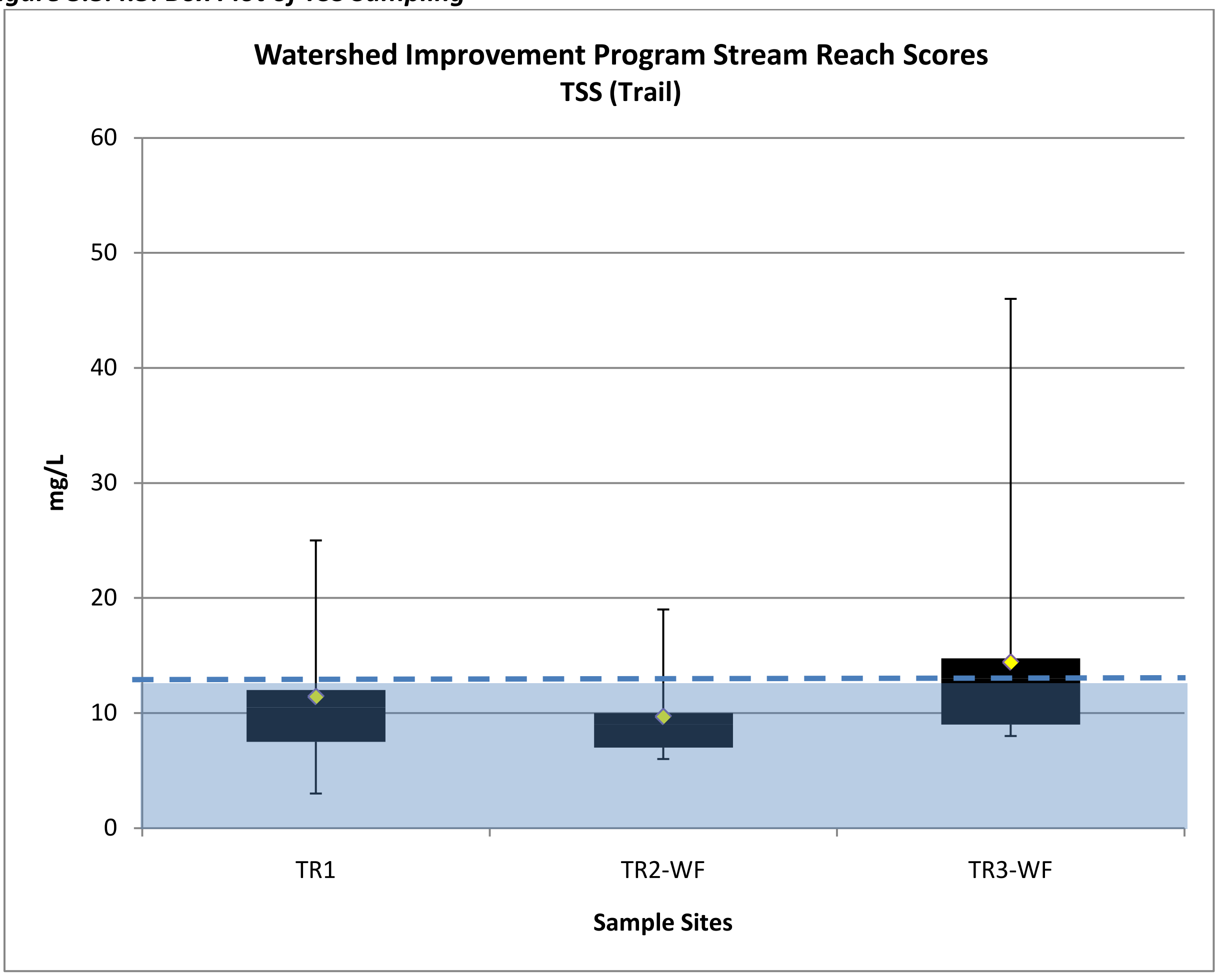
During stream walks in the watershed evidence of a variety of wildlife was observed, indicating the presence of deer, raccoons, opossums, squirrels, as well as several beaver dams. Large concentrations of animal feces near streams can be a source of elevated nutrient levels. Nutrient contributions from terrestrial species are typically less significant than contribution by waterfowl and beavers. However, feces deposited on the land surface can result in the introduction of nutrients to streams during runoff events. The buffers along the stream may provide the most desirable habitat for wildlife, potentially concentrating wildlife sources of fecal coliform in the stream corridor. We do not have any data on how many domestic pets are in Trail Creek, but dog pens were observed in the residential areas. However, there is not enough data to support pet waste as a significant contributor to the fecal coliform levels found in the stream.

Figure 3.3.4.2 Sewer Spills and Septic Tanks in Trail Creek Drainage Basin



Total suspended solids are the amount of sediment suspended in the water of the stream. The amount of suspended sediment can be increased by bank erosion and bed scouring caused by the increased runoff and water velocities entering a stream as discussed in earlier sections of this report (see sections 3.1.2: Trail Creek Stream Bed, Bank and Buffer and 3.1.3: Potential Stressors Effecting Trail Creek's Stream Assessment Scores).The score for total suspended solids was elevated in 16 water quality samples. It is important to note, however, that the benchmarks are meant to represent a healthy stream in dry weather conditions. On two of dates in which a sample exceeded the benchmark for TSS, there was rain on the night before sampling occurred. Figure 3.3.4.3 shows box plots of the TSS sampling data.

Figure 3.3.4.3: Box Plot of TSS Sampling



Nutrient levels are one of the most difficult water quality parameters to calibrate in flowing streams due to differences in local geology, historical landuse, stream discharge, and stream size. Increased nutrient concentrations can come from a variety of sources such as: permitted discharges, fertilizers for landscaping and agriculture, and even natural sources such as decomposition of leaf and limb matter. Anthropogenic nutrients in streams can cause algal blooms, which may reduce dissolved oxygen levels and reduce water clarity. Nutrient inputs may also increase the breakdown of leaves and wood in the stream, reducing the amount of food available for macroinvertebrates and fishes. Municipal and industrial entities have permission through NPDES permits to discharge stormwater and treated wastewater into streams. Overland flow of runoff from developed watersheds contains nutrients from lawn and garden fertilizers as well as additional organic debris (leaves and lawn clippings) that are easily washed from urban surfaces. Agricultural areas can also contribute to nutrient increases through poor manure and fertilizing practices and erosion from plowed land. Our observations during stream walks indicate that some residents fertilize their lawns, and in reach 1l cattle were given direct access to the stream. Runoff from permitted discharges and developed land uses can convey increased nutrients found in the stream.

In this study, we sampled three forms of nitrogen: nitrate (NO_3), ammonium (NH_4) and total nitrogen. Nitrate and ammonium measure forms of nitrogen that are dissolved in the water column and available for uptake by biota, while total nitrogen includes both the dissolved ammonium and nitrate as well as organic and particulate forms of nitrogen. Two forms of phosphorus are also sampled in this study: phosphate (PO_4) and total phosphorus. Phosphate is dissolved and inorganic, meaning that it that is easily utilized by plants and microbes. Total phosphorus includes both inorganic PO_4 and organic and particulate forms of phosphorus. In this study, benchmarks for total nitrogen, nitrate, ammonium, total phosphorus and phosphate were set based on scientific literature values (Herhily et al. 2008, Dodds et al. 2002) and baseline data from this study, creating both an upper and lower bound for nutrients (See table 3.3.3.1).

While no one sampling event produced a measurement above the upper benchmarks for any of the study nutrients, nitrate, ammonium and total nitrogen in all samples were higher than values from other studies in Georgia piedmont streams. Both phosphate and total phosphorus levels are very low in Trail Creek, though. Still, it is important to track inputs of phosphorus; if phosphorus were to be added to these streams and nitrogen remained at moderate levels, it would likely cause significant changes in both algal biomass and organic matter breakdown. Figure 3.3.4.4 shows the summary of nutrient samples for Total Nitrogen and Figure 3.4.4.5 shows the summary of nutrient samples for Total Phosphorous.

Figure 3.3.4.4 Box Plot of Total Nitrogen

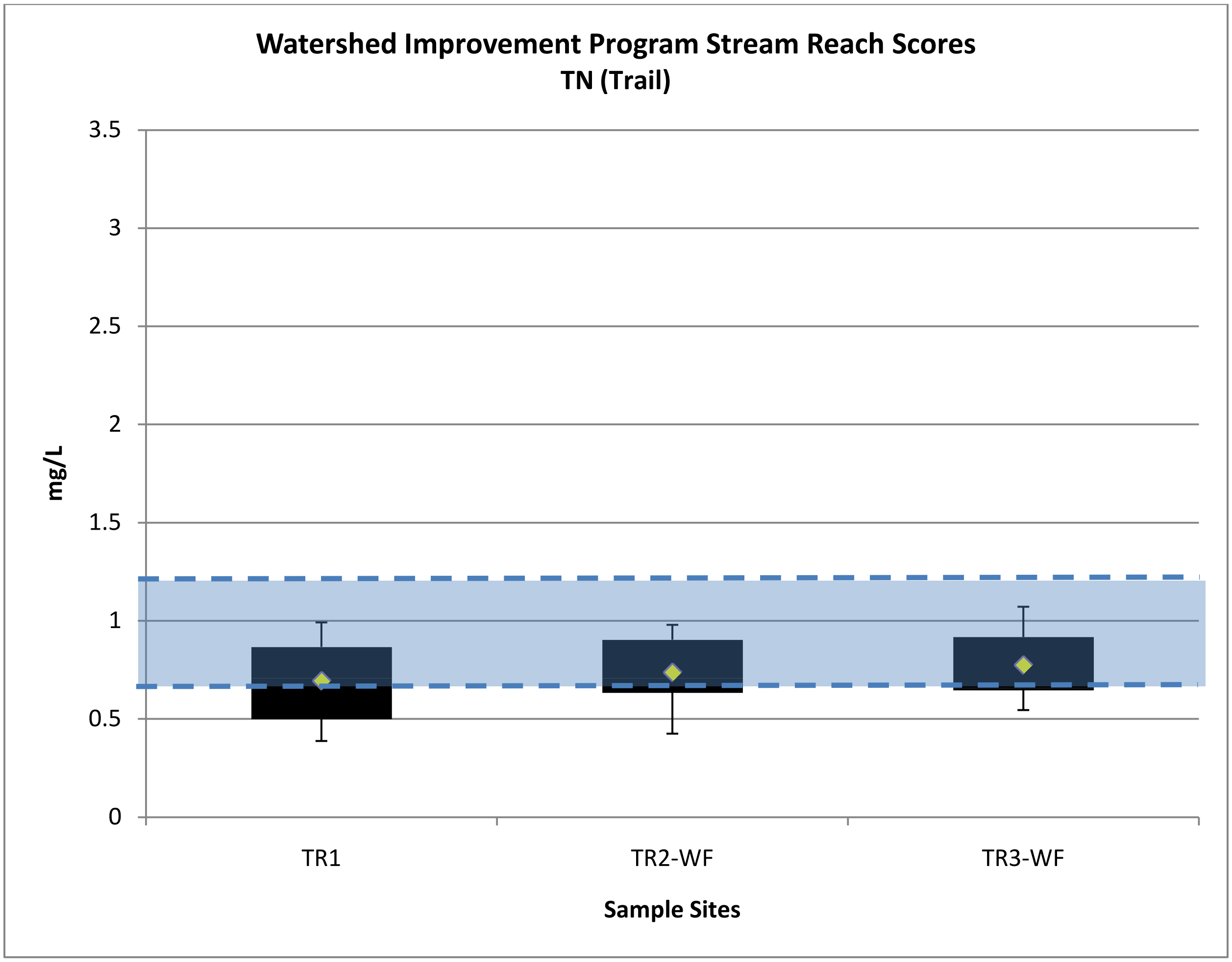
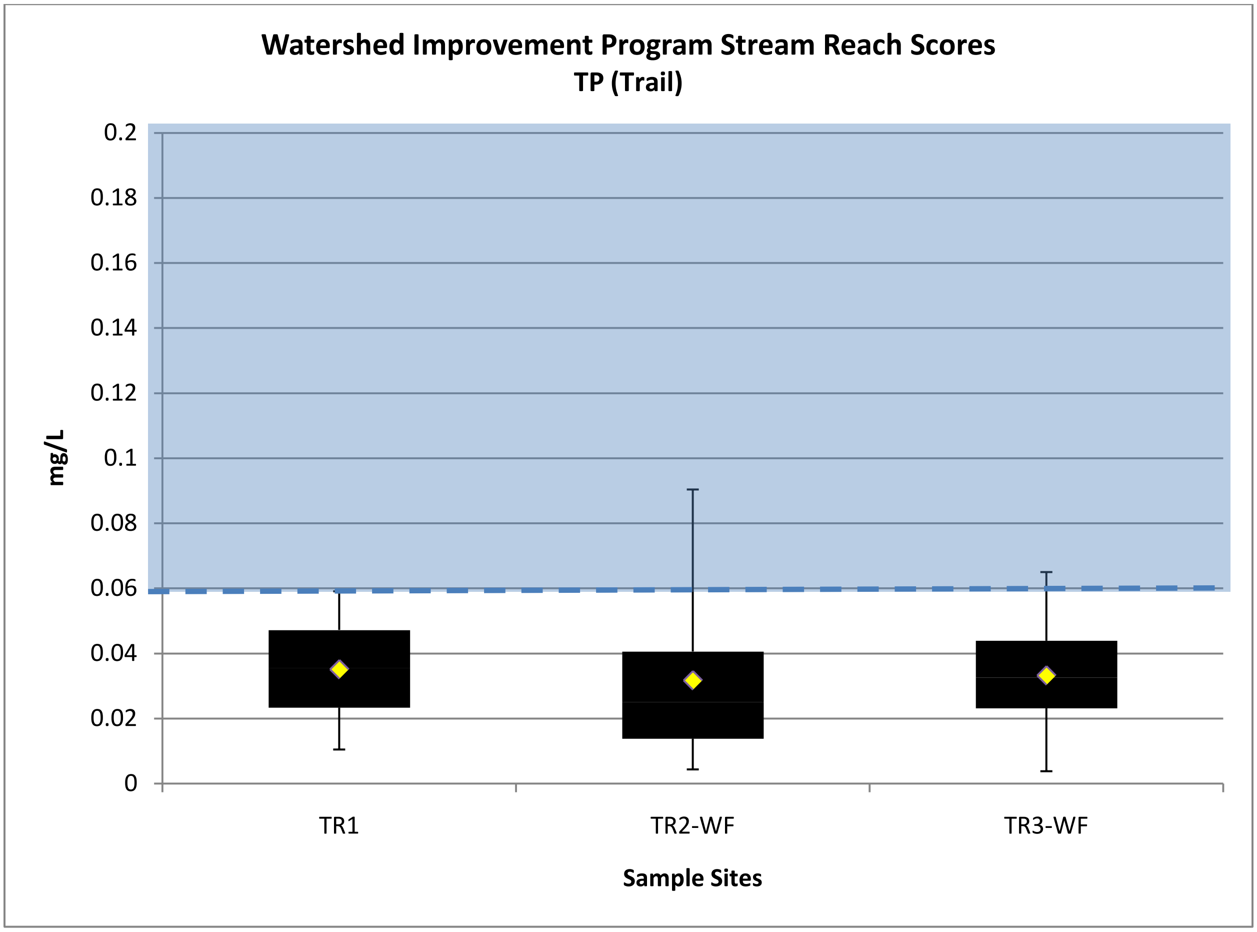


Figure 3.3.4.5: Box Plot of Total Phosphorous



Increased nutrient concentrations can come from a variety of sources such as permitted discharges, fertilizers for landscaping and agriculture, and even natural sources like decomposition of leaf and limb matter. Municipal and industrial entities have permission through NPDES permits to discharge stormwater and treated wastewater into streams. Overland flow of runoff from developed watersheds contains nutrients from lawn and garden fertilizers as well as additional organic debris (leaves and lawn clippings) that is easily washed from urban surfaces. Agricultural areas can also contribute to nutrient increases through poor manure and fertilizing practices and erosion from plowed land. Our observations during stream walks indicate that many residents fertilize their lawns, and in some reaches we found fertilizer bags stored within the stream buffer. Runoff from permitted discharges and developed land uses can convey increased nutrients found in the stream. The impacts of elevated nutrient loading can result in increased algae growth. Excessive growths of attached algae can cause low dissolved oxygen levels, odors, and poor habitat conditions for aquatic organisms (WA Department of Ecology, Chapter 3). Algal samples were collected by UGA in Trail Creek and analyzed for chlorophyll A and nutrient contents. Overall, seasonal patterns were noticed and correlations can be drawn between the increases in Total Nitrogen and the amount of chlorophyll A present in the algal samples, particularly during winter months. Future sampling is necessary to better define this relationship. Once we have this data we will know more about how much nutrients are impacting the aquatic habitat in Trail Creek. While increased nutrient levels are not a regulatory violation, they can have regulatory consequences by impacting other water quality parameters.

3.4 Conceptual Model of Trail Creek – West Fork Conditions and Concerns

In order to understand the health of the Trail Creek watershed, we utilized three main methods of data collect that provide us with information on stream health: conducting a physical stream assessment, collecting biological Scores, and collecting water quality data. A conceptual model was created to trace these indicators back to their likely sources and identify areas of particular concern in Trail Creek.

Indicators

The three indicators for this study are Water Quality Data, Biological Scores, and Stream Assessment Scores. Water Quality Data come from three sources: monthly grab sampling, datasonde long-term monitoring instruments, and wet weather sampling. This data is then compared to water quality benchmarks created using the Georgia Water Quality Standards and comparable studies of water quality. Biological Scores were obtained by collecting and analyzing macroinvertebrate and algae data. Stream health cannot be solely defined by water quality alone. That is why it is important to conduct physical stream assessments as well. Stream walks were used to gain an understanding of the West Fork of Trail Creek's physical health from the headwaters to the culvert at Collins Industrial Boulevard.

Impacts

Moving up the model, we looked at the local impacts that lead to the indicators mentioned above. These are the "evidence" that a stream is suffering from some type of water pollution. These indicators include specific impacts with a direct correlation to Water Quality Data like regulatory standards violations and missed benchmarks stemming from algal growth and decreased water quality. Degraded aquatic habitat and impaired aquatic life affect biological scores. In the physical assessment of the stream, we focused on the bed, banks, and buffers and noted the particular impact of erosion, incision, aggradation, and degraded riparian habitat in Trail Creek.

Stressors

A variety of more broad stressors cover some of the larger issues of water quality. These stressors include nutrients, pathogens, and chemicals—all important contaminants to be mindful of in stream studies. More importantly in Trail Creek, these stressors include Increased Peak Flow and Runoff Volumes, Riparian Disturbance, and Sediment, which upon analysis are likely the most important contributors to the declining health of the watershed.

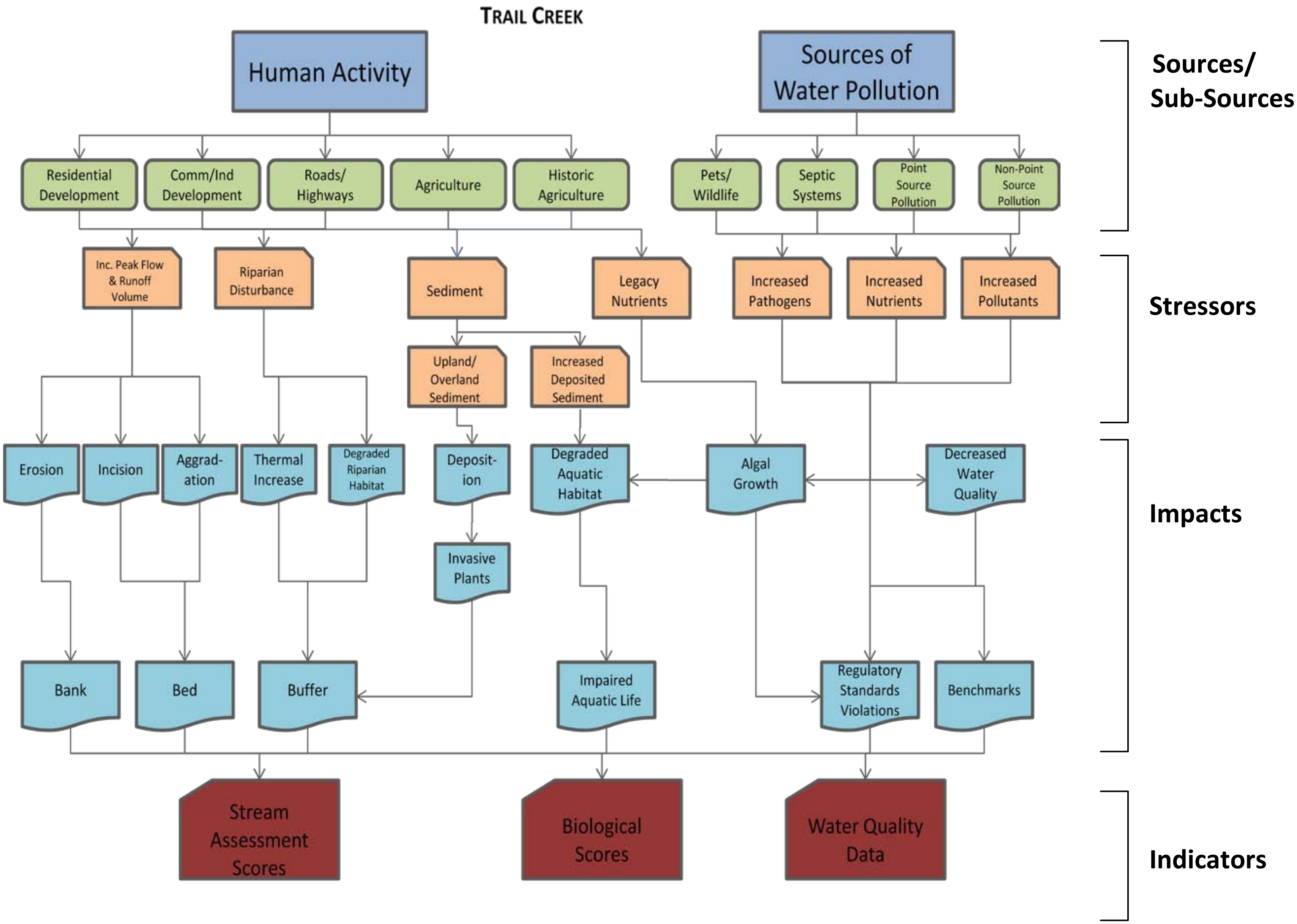
Sources/Sub-Sources

Finally, more global sources of stream degradation include Urban Development, Historical Agriculture, and other Sources of Water Pollution. In this study of Trail Creek, it is evident that a majority of the issues in this watershed stem from human sources, particularly Historical Agriculture and Urban Development. Sources of Water Pollution also contribute to poor water quality, but the data does not suggest that the impacts are as great as Historical Agriculture and Urban Development.

Summary

Overall, as mentioned, the driving factor on the condition of TCWF is human activity. We can point to three key stressors as having impacts on aquatic life, hydrologic function, and water quality. These stressors are sedimentation and hydromodification due to development, fecal coliform contamination, and excessive nutrients. Land disturbance in the form of historical agriculture as well as more recent development has contributed to stream sedimentation. This sediment is not readily moving through the system due to the stream's inability to generate enough energy and flow as a result of low grade and the presence of beaver dams, wetlands, and NRCS lakes. Fecal coliform contamination has already resulted in the stream being listed on the state's 303(d) list; however, the sources of this contamination are uncertain at this time and the data shows no signs of a continuous source. Further source identification is needed. The lack of stormwater BMPs and noted urban and suburban development are likely the dominant factor in nutrient loading from nonpoint sources in TCWF. However, there are methods for controlling some nutrient inputs, such as fertilizers, including education and outreach.

Figure 3.4.1 Conceptual Model of How Pollution Occurs in Streams



Chapter 4: Identification of Management Needs

4.1 Summary of Management Needs

As mentioned in the previous section, it is human activity that has had the greatest impact on the Trail Creek watershed. The headwater areas of the Trail Creek watershed are impacted due to past agricultural land uses which have aggraded the stream channels, and due to existing agricultural practices allowing cattle access to streams. Despite these impacts, physical assessments indicate that nine of the ten reaches surveyed approached or exceeded suboptimal conditions (the benchmark threshold). Currently, high flow is not an issue in this watershed, except in localized areas with high imperviousness; therefore, centralized and distributed BMPs are not needed except in the mid portion of the watershed where there is a high degree of development and imperviousness (catchments 122, 123, 125, and 142). High priority should be given to protection efforts, particularly preservation of riparian buffers and preservation of existing beaver ponds that are providing a flow control and water quality benefit, and to ensuring adequate flow and water quality BMPs for new development such as Low Impact Development (LID)[1]. The existing stormwater management ordinance and development regulations should be updated to require or encourage the use of the LID BMPs that preserve and minimize the site's natural hydrology. For restoration efforts, priority should be given to livestock BMPs and streambank restoration projects in pasture areas. Other BMPs are considered important, but not as important in preventing future degradation and stabilizing existing conditions. These include stream channel restoration and streambank restoration projects in the lower reaches of the watershed where high levels of imperviousness and stream channel aggradation exist, as well as targeted instream grade control and streambank stabilization. Bacterial source tracking is also very important as this information is key in selecting management options.

4.2 Best Management Practices to Be Utilized in Trail Creek – West Fork Watershed

4.2.1 Stream Channel Restoration

Stream channel restoration BMPs should target downstream reaches after flow has been stabilized upstream in order to ensure their lifespan and effectiveness.

Stream channel restoration

Stream channel restoration involves removing historic sediments, restoring the bankfull channel at the approximate pre-settlement elevation, and restoring the bankfull channel at the current floodplain. The regenerative approach involves filling and stabilizing the channel to the current floodplain. Characteristics include:

- Producing more gradually sloping banks
- Reconnecting a stream to the floodplain
- Converting a stream from a straight to a meandering channel
- Restoration of riffles (shallow areas where flow passes over a gravel bed)

[1] Low Impact Development is a development design technique that seeks to mimic the natural hydrology of a site to reduce water quality and quantity impacts. Preservation of high infiltration areas, directing runoff to natural vegetation, and incorporating distributed BMPs are among the strategies used when designing LID.

- Restoration of pools (deeper, more slow-flowing areas)
- Installing rock or wood structures that promote natural stream flow patterns
- Revegetation of banks
- Maintenance and monitoring of restorative efforts

Instream grade control

Instream grade control is a type of restoration that alters the existing channels and adds structures to the channels that reduce velocity and downstream erosion.

4.2.2 Sewer Line Maintenance/Replacement/Study

This strategy involves replacing or repairing cracks or other sources of leaks in sewer pipes.

Closed Circuit Television (CCTV) study of sewer pipe condition

A CCTV study involves the use of video equipment to evaluate the condition of sewer pipes and identify those that require maintenance or replacement. This would target the downstream segments where sewer line currently exists and eventually be extended to the newer infrastructure.

Enhanced CIP for sewer pipe maintenance and replacement (potential enhancement of current programs)

A capital improvement plan/program (CIP) includes an enhanced schedule for routine sewer pipe maintenance and replacement of leaking pipes.

Conduct enhanced bacteria study

A field study designed to observe indicators of bacteria loading can help identify the major sources of bacteria in a watershed and lead to more successful management efforts.

Enhanced inspections/maintenance of onsite wastewater

Onsite wastewater facilities can be sources of nutrients and bacteria when not maintained properly. Enhanced efforts to inspect such facilities in the Trail Creek watershed and promote their proper maintenance could help reduce pollutant loading.

Evaluation of retrofit of oxidation ponds for water quality

Several oxidation ponds exist within the Trail Creek watershed and could be evaluated for their effect on downstream water quality.

4.2.3 Streambank/Riparian Area BMPs

4.2.3.1 Priority Streambank/Riparian Area BMPs

Pasture BMPs limiting cattle access to streams
This BMP involves using fencing to block cattle access to streams. Alternative water sources would need to be provided to the cattle. This practice typically involves restoration of the fenced riparian buffer.

Streambank restoration

Streambank restoration involves the conversion of vertical banks to gradually sloping banks, which are then stabilized and vegetated.

Riparian buffer preservation (education and conservation easements)

This activity involves preventing the future disturbance of vegetation along streams by purchasing property rights, either through a conservation easement or fee simple purchase.

4.2.3.2 Secondary Streambank/Riparian Area BMPs

Streambank stabilization

Streambank stabilization involves adding natural materials or structures to banks to reduce erosion and provide stability. Natural, less structural materials are preferred, but riprap and similar materials may be required along severely unstable reaches.

Riparian buffer revegetation

Riparian buffer revegetation, or restoration, involves the re-establishment of natural vegetation along streams where it has previously been removed or destroyed. This activity is usually part of a stream restoration project.

4.2.4 Citizen Education

Citizen Education Efforts

Citizen education is an extremely important method for improving stream health. Several different methods would be used for educating citizens, as outlined below. Many of these strategies would be utilized county-wide, not just in Trail Creek; however they are an important part of this WMP. Each strategy includes:

1) Program Description
2) Target Audience
3) Goals of Program (Broad)
4) Expected Outcome (Quantitative)

Stream Clean-Ups

1) Residents remove trash and tires from the stream bed, banks, and buffer. Volunteers may also be recruited using Community Connection's network of volunteers. Partner with the Solid Waste Department in order to have access to roll-off containers for disposal of trash.
2) Residents living in the target basin, residents living or owning property near streams.
3) To improve stream habitat, connect residents to their local environment, and to gain resident investment in the larger Watershed Improvement Program.
4) 500 feet of stream cleaned up and involvement of 15 residents per basin. Also measure the tons of garbage removed from the stream and buffer.

Fertilizer Reduction Program

1) Residents are taught how to test the soil to determine how much fertilizers they need. They are taught how and when to fertilize properly, using a fertilizer with nitrogen/phosphorous/potassium ratios recommended by UGA Cooperative Extension Office. Residents can be engaged during the neighborhood meetings but will also be mailed test kits. How many kits are sent in by residents to be tested is a measure of some behavior change. Residents will be asked to create a “no fertilizer and no mowing zone” within x feet from the stream, and the change in buffer width over time can be a measurement of behavior change. The landscaping businesses currently used by basin residents will also be engaged and asked to use only what fertilizers are necessary as prescribed by UGA Cooperative Extension. Residents will be asked to show the soil testing results to their landscapers and request that only the necessary amounts of fertilizers are applied during the appropriate season. Signs may be posted that can be changed to give residents a “green” or a “red” light for fertilizing based on when the next rain event is likely to occur.
2) Home owners in target basins, approach by neighborhood or even a collection of streets.
3) Overarching goal is to reduce improper fertilizer application and therefore to reduce nutrient levels in the stream. The stream will be sampled before, during, and after the implementation of the program. During the program complimentary media will run on local media outlets.
4) Outcomes could include:
    a. Enlist at least 50% of households in a residential neighborhood to sign a pledge to eliminate or reduce fertilizer application to once per year. (Follow up periodically to confirm ongoing adoption.)
    b. Have 25 number of residents send in soil testing kits per year.
    c. Change in buffer width over time.
    d. Fertilizer levels in water before and after program implementation.

Other Desired Behavior Change

1) Reduction of soaps and detergents in runoff
    a. Give residents car clings that remind them to wash their car on the lawn.
    b. Offer coupons for local car washes. Can track how many coupons are redeemed.
2) Reduction of pet waste in runoff
    a. Give out free doggie bags
    b. Have residents and their children do “poop patrol,” putting flags in pet waste left on the ground. Repeat 6 months later and measure the change in the number of flags distributed for the same area.
3) Reduction of leaf and lawn litter that enter the stormwater system
    a. Leave door hangers explaining the harm done by lawn debris on area houses.
        i. Do a visual assessment of lawn debris and leaves in the gutters and stormdrains before and then 6 months after program implementation.

Businesses

1) Engage businesses in the Stream Savers Program. This program is still in development but includes business participation in the following types of activities. An “ACC Green Business

Award" program might also be effective, and would involve participating in education and behavior change activities designed by ACC Stormwater, Keep Athens-Clarke County Beautiful, ACC Water Conservation, and ACC Recycling.

- Hosting a rain barrel workshop for the general public
- Installing a rain barrel with educational signage on the business property
- Having a "Stream Saver Special" food item or product for sale
- Completing a stormwater audit of the business grounds
- Organizing a team of business employees to take part in a stream clean-up or other environmental service day
- Adopting a stream or highway
- Hosting a visit from the Stormwater mascot, Tortooga
- Completing a water conservation audit
- Watching a stormwater or water quality related DVD during a staff meeting
- Converting to non-toxic cleaners for cleaning the workplace
- Participating in a lunch-n-learn lecture hosted by ACC Stormwater
- Making stormwater education materials available for customers

Complementary Media

Complimentary media campaigns will be run on local media outlets to increase awareness of and advertise for the programs themselves, as well as to educate ACC citizens in general about ways they can protect the health of their watersheds. Advertising for localized neighborhood programs to the larger general audience will help to build awareness of the watershed improvement programs ACC Stormwater will offer and hopefully increase attendance at future public meetings and workshops. Staff should create a media campaign approach that speaks to the interests of the Athens population, but should also draw from resources that already exist from national stormwater pollution reduction campaigns.

4.2.5 Other BMPs

Preservation of beaver ponds and wetlands

This activity involves preventing the future disturbance of beaver ponds or wetlands by purchasing property rights, either through a conservation easement or fee simple purchase.

Waterfowl management

It is generally desirable to have waterfowl habitat within a watershed ecosystem. However, waterfowl can be a significant source of bacteria and nutrients in waterbodies, and a number of management strategies are available to control their populations. The following strategies can be used to discourage the overuse of waterbodies by waterfowl, particularly Canadian geese:

- Install devices that repel waterfowl from a waterbody without causing harm to the birds or other wildlife (custom windmills, eagle-shaped kites, flashing lights, etc.)
- Reduce or eliminate fertilization and irrigation near waterbodies.

- Replace lawn areas along waterbodies with shrubs, yucca plants, or other vegetation that is less attractive to waterfowl.
- Build in trees, shrubs, rocks and other natural obstructions that provide habitat for predators.

These strategies should also be used to prevent BMP retrofits, especially pond retrofits and stormwater wetlands, from being accessed by problematic waterfowl.

4.3 Evaluation and Location of BMP Priority Areas

The BMPs above were further evaluated to select the most promising BMPs for detailed modeling and assessment by individual catchment. Tetra Tech, the environmental consultant used on this project, used available observed and simulated data to designate which catchments presented the greatest management needs, including

- Catchment Loading: estimated total loading from overland runoff in the watershed, including Total Nitrogen (TN); Total Phosphorus (TP); Total Suspended Solids (TSS). These estimates are from the LSPC watershed model results of existing conditions.
- Observed Monitoring Data: measured water quality data including TN, TP, TSS, Dissolved Oxygen (DO), Fecal Coliform (FC), Biological Oxygen Demand (BOD), and Turbidity (as discussed in Section 3.3.3).
- Flashiness Index: a measure of the peak flow of streams. These estimates are from Tetra Tech's modeling of existing conditions using the project's LSPC watershed model.
- Aquatic Habitat Score: indicators of overall stream health from the project characterization reports.
- Total Stream Segment Score: an indicator of overall stream condition from the project's characterization reports.

As noted above, all of the BMPs in the previous section are recommended for the watershed improvement strategy. However, different combinations of BMPs were selected for different catchments. The BMPs were screened for their potential effectiveness and implementation feasibility based on each catchment's (1) management needs, and (2) existing types and intensities of land cover. Each strategy included a number of distributed and centralized engineering BMPs, streambank and riparian area management, and citizen education. The BMPs selected for more detailed catchment assessment were considered the most promising BMPs; however, other BMPs options on the menu could be effective as well in a given catchment and should also be considered in the future.

Priority reaches for restoration and preservation were selected according to which reaches were rated as moderately degraded during ACC's field assessment (Section 3.1). Sites were evaluated to ensure that selected reaches exhibited moderate bank erosion, channelization, etc., and selected reaches did not have conditions that would cause major constraints, like unusually high banks or existing structures.

The following figure (Figure 4.3.1) show each catchment's high priority management needs and opportunities for the Trail Creek Watershed. For the watershed, a map is provided showing overall management needs and high priority BMPs, by catchment. The figures also highlight secondary management needs that should be addressed as resources become available, and the associated secondary BMPs. Figure 4.3.2 shows restoration and buffer preservation opportunities in Trail Creek – West Fork.

Figure 4.3.1 Trail Creek- West Fork Management Needs and Recommended BMPs

Figure 4.3.2 Trail Creek – West Fork Restoration and Buffer Preservation Opportunities

4.4 Estimated Load Reductions of Best Management Practices

Modeling analysis was conducted to assess the management needs and BMPs put forth in this plan. The protection/preservation measures recommended, such as LID for future development projects, were not modeled in the assessment of watershed improvement BMPs since these measures do not address existing impairments. However, these protection measures are critical in maintaining the watershed improvements implemented and in addressing potential future impacts, and thus are included in the watershed management plan.

4.4.1 Characteristics of the Management Plan Strategy

The management plan strategy has a number of key characteristics to achieve:

- 25 percent of the problem pastureland with livestock is targeted for stream buffer restoration, fencing, and alternative water sources (Trail Creek catchment 137 only).
- 25 percent of the impervious area is managed in the targeted catchment using the centralized and decentralized (engineering) watershed improvement BMPs.
- 50 percent of the residential area is targeted for a homeowner nutrient reduction program.
- 25 percent of the unvegetated stream buffers are restored in the targeted catchments.
- 25 percent of the good candidate streambank/channel restoration sites are implemented.

4.4.2 Modeling and Assessment Approach

Tetra Tech used the Best Management Practices (BMP) Evaluation Module to assess the effectiveness of management measures at the site and catchment level, and to estimate the cumulative effectiveness of the management strategy at the watershed level if implemented. The BMP evaluation module simulates BMP control of flow and water quality. The data inputs for the BMP Module were generated from the watershed model developed for the ACC study watersheds. The model used watershed hydrology and water quality data from the years 2001 to 2007 to estimate the annual pollutant load reduction and peak flow control if BMPs are implemented.

Several BMPs were not appropriate to assess in the BMP Evaluation Module: agricultural BMPs, buffer and stream restoration, the homeowner nutrient reduction program. These BMPs were evaluated using the project's watershed model and Geographic Information System (GIS) coverages of the study watersheds, and then "rolled into" the BMP Evaluation Model results to generate cumulative results for each strategy (except the stream restoration projects, which are reported separately).

Tetra Tech also assessed how well the management strategies meet the proposed water quality benchmarks. Using monitoring data from the three pilot watersheds (Section 3.3.3), Tetra Tech identified a catchment at the base (or bottom) of Trail Creek watershed that met the midpoint of the TP and TN benchmark ranges for instream concentration. Since the nutrient concentrations at the base of the watershed reflect land cover runoff from the entire watershed, existing land cover loading rates for TP, TN, and TSS from the Trail Creek watershed were used as target loading rates and used to develop target annual loading for all the county's watersheds, including Trail Creek itself.

To express the uncertainty of the target loading, a range was established around the target loading rate. The proposed water quality benchmarks were used as guidance for this range. The concentration-based benchmarks represent a 25 to 60 percent range around a midpoint. To be conservative, Tetra Tech established a range for the target load using a ± 25 percent around the target loading rate for each watershed. Then pollutant loading targets were used to evaluate the effectiveness of the moderate and aggressive strategies in meeting the recommended instream water quality benchmarks.

4.4.3 Modeling Results

The modeling results below are reported in several ways. First, there are bar graphs comparing annual pollutant loading under existing conditions and the target pollutant loading needed to achieve water quality benchmarks. Second, watershed maps compare catchment loading under existing conditions and the suggested management strategies. As the watershed improvement BMPs are implemented, it will be important to monitor stream conditions to determine how the load reductions achieved affect water quality compared to the water quality benchmarks (to be discussed in Section 4.6).

The watershed improvement strategy in Trail Creek – West Fork gives priority to protection efforts. This strategy produces a 7 percent reduction in TN, a 7 percent reduction in TP, and a 2.3 percent reduction in TSS. These are only moderate reductions, but overall Trail Creek's existing loading meets the water quality benchmarks. Figures 4.4.3.1 through 4.4.3.3 display the load reductions for these constituents. Figures 4.4.3.4 through 4.4.3.6 demonstrate how pollutant loading changes in each catchment of the watershed.

Figure 4.4.3.1 Total Nitrogen Anticipated Load Reductions

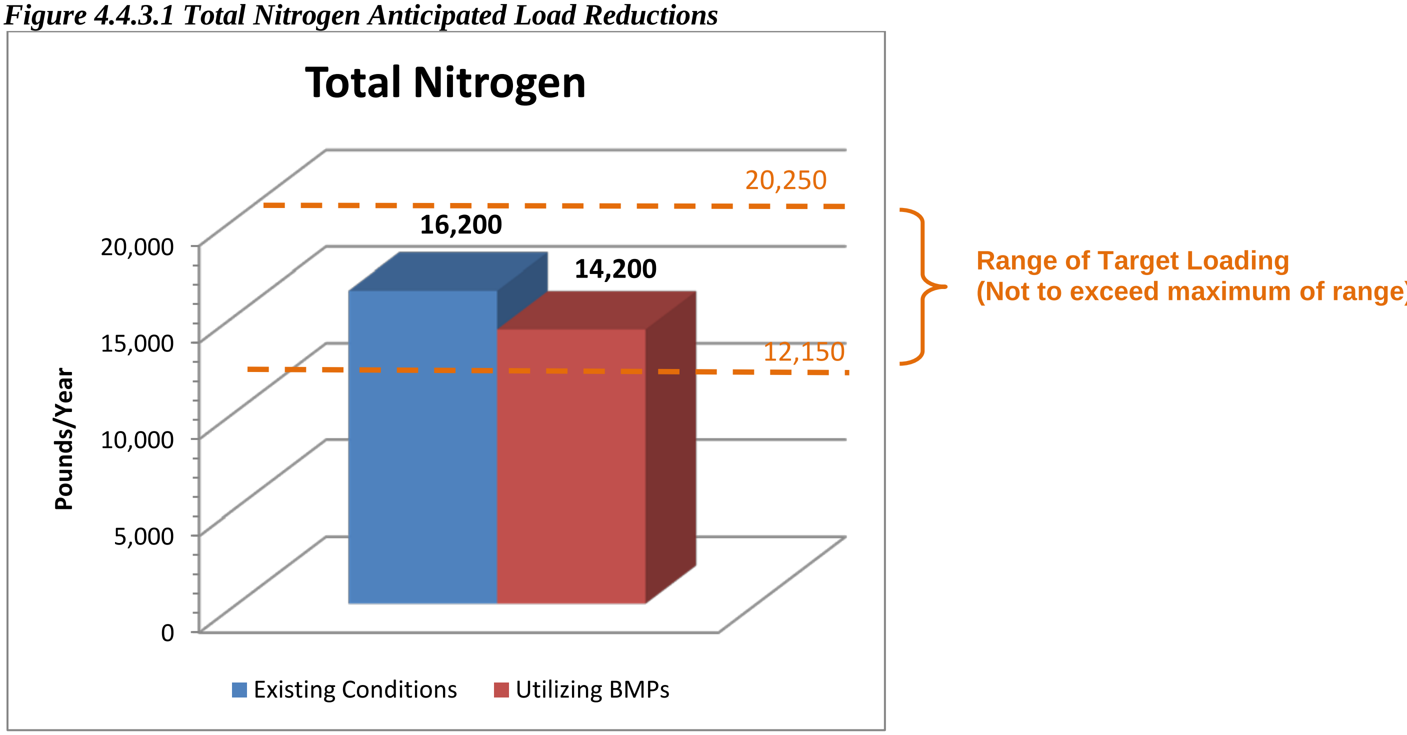


Figure 4.4.3.2 Total Phosphorous Anticipated Load Reductions

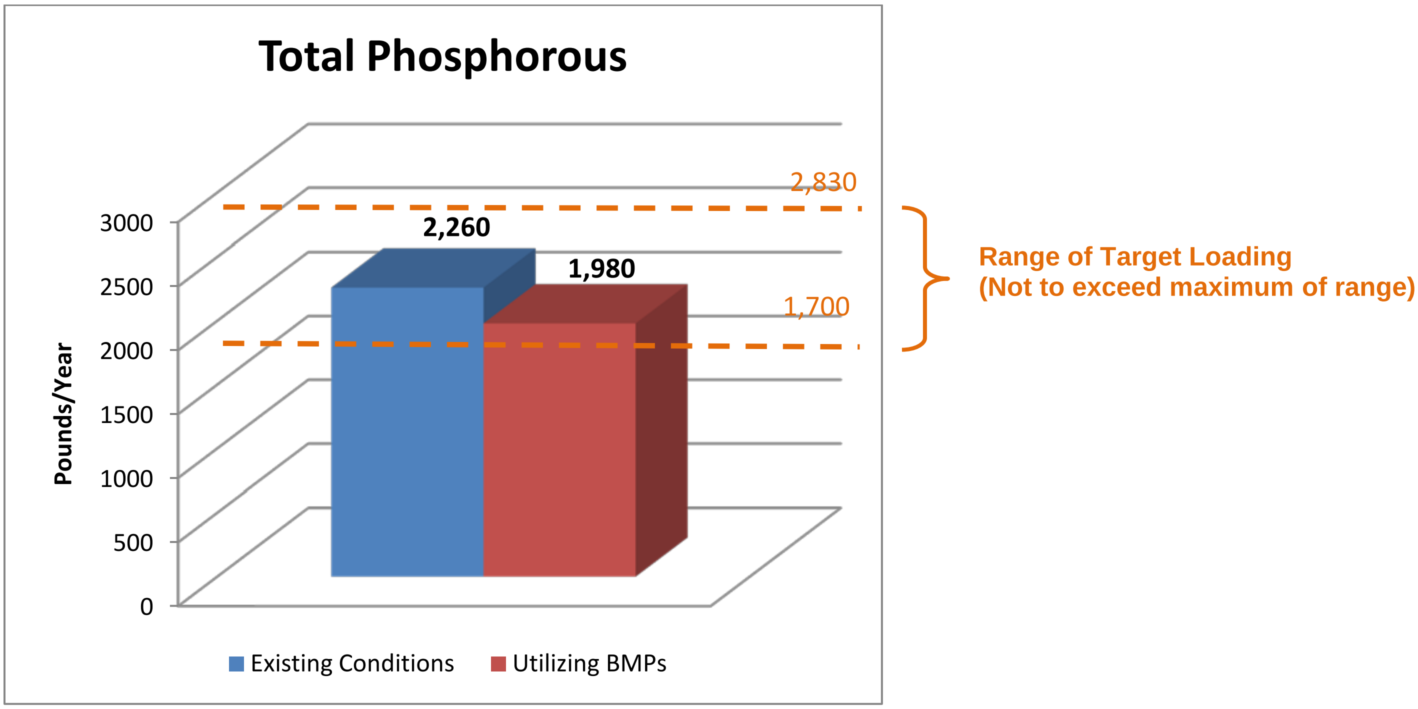
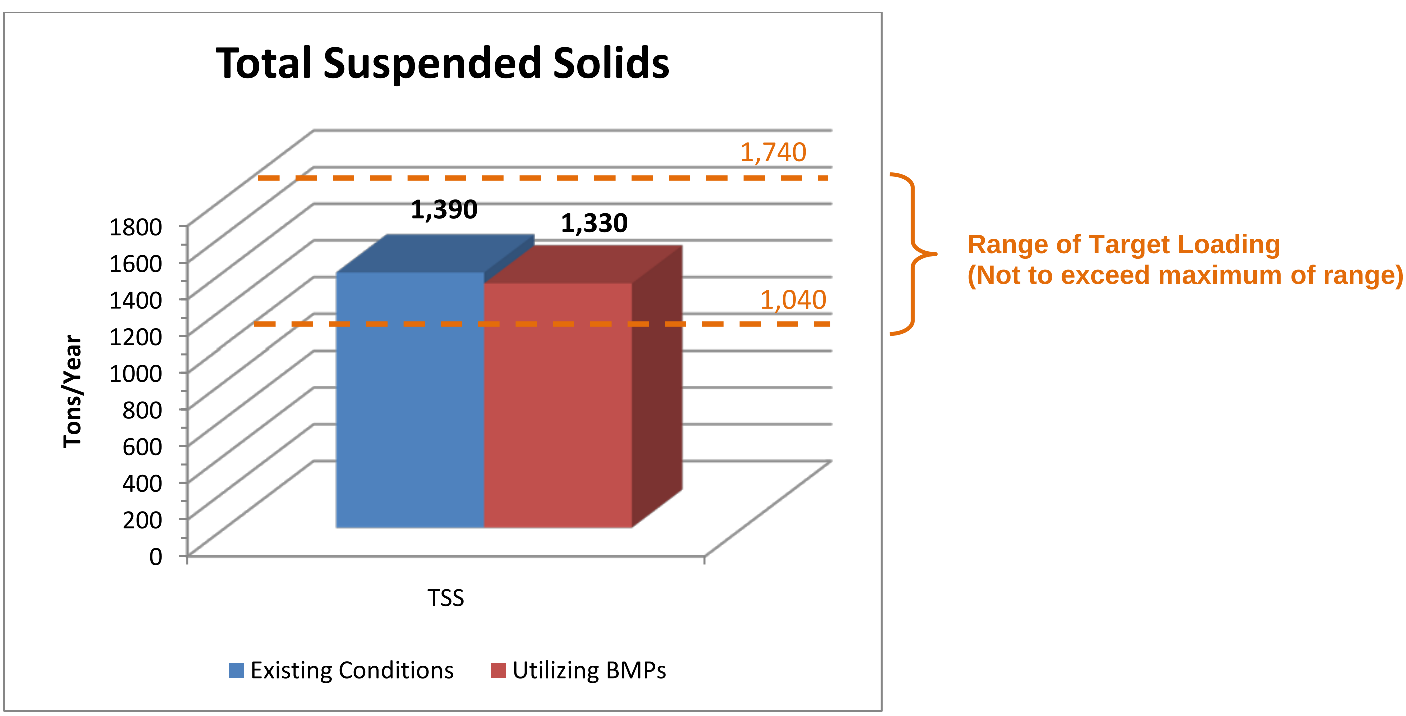


Figure 4.4.3.3 Total Suspended Solids Anticipated Load Reductions



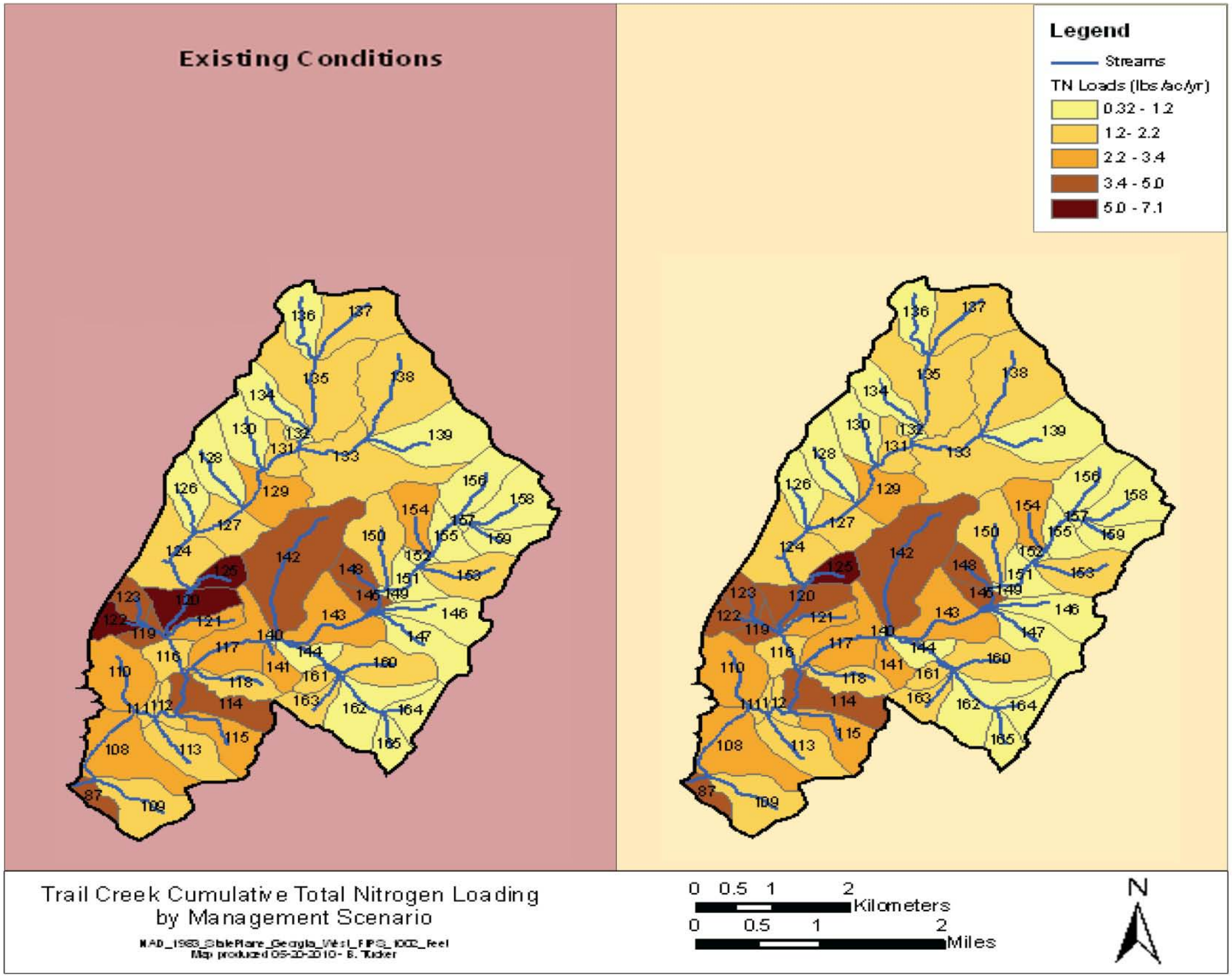


Figure 4.4.3.4 Trail Comparison of TN Loading in Catchments

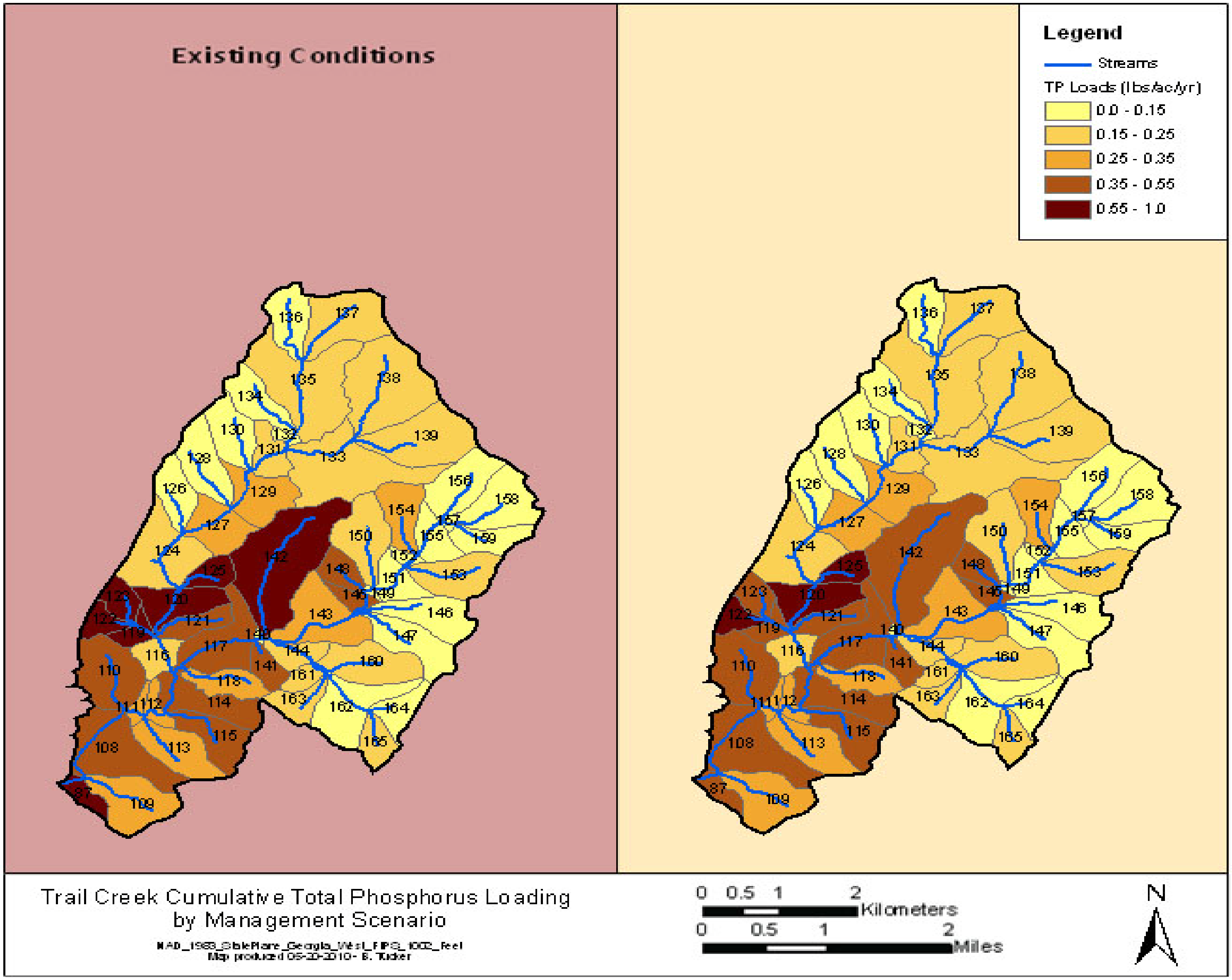


Figure 4.4.3.5 Trail Comparison of TP Loading in Catchments

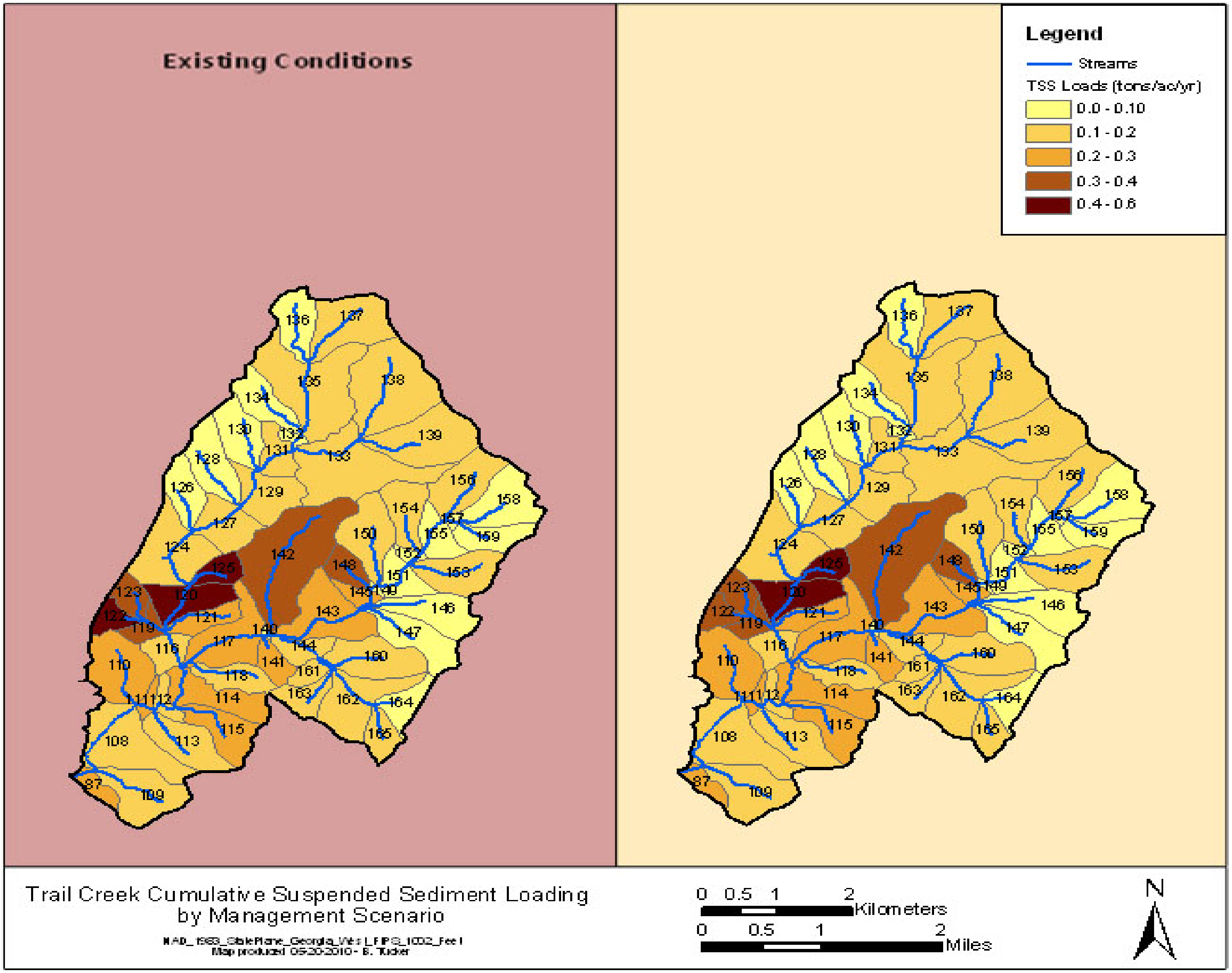


Figure 4.4.3.6 Trail Comparison of TSS Loading in Catchments

4.5 Implementation Cost and Schedule

Implementing this plan will require significant amounts of funding to achieve the load reductions mentioned in the previous section. These reductions will also not occur rapidly and therefore a long-term strategy for both cost and implementation is necessary. Table 4.5.1 provides a 10-year outline for the implementation of the aforementioned BMPs, as well as a lifetime cost estimate.

Activity	Priority	Schedule (Year)										Costs ($)
		1	2	3	4	5	6	7	8	9	10	
Agricultural BMPs												
Pasture BMPs	1		X	X								$41,000
Stream Channel Restoration												
Stream Restoration	2						X	X	X	X		$700,000
Sewer Line Maintenance/Replacement/Study												
Enhanced Bacteria Study	1	X	X									$20,000
Sewer Pipe Condition Study	P			X	X	X	X					$420,000
Streambank/Riparian Areas BMPs												
Buffer Preservation	1	X	X	X	X	X	X	X	X	X	X	$200,000
Buffer Restoration	1			X	X	X	X	X	X	X		$178,000
Citizen Education BMPs												
Citizen Education Efforts	1	X	X	X	X	X	X	X	X	X	X	$150,000
											Total	$1,709,008

Notes:

1 = First Priority
2 = Second Priority
P = Potential BMP

4.6 Evaluation Methods for Measuring Success

In order to ensure the success of the management measures outlined in this plan, an adaptive management approach is necessary. Continued evaluation, both quantitative and qualitative, will help determine the effectiveness of the variety of BMPs used. All BMPs will be monitored upon implementation, but specific evaluations will take place at 5 year intervals. At this time, if necessary, revisions will be made to this plan in order to improve its effectiveness at enhancing watershed health.

4.6.1 Quantitative Evaluation Techniques

In assessing the current conditions in the West Fork of Trail Creek, we have a baseline of data to compare the expected BMPs' improvements against. In order to assess what improvements have been made, follow-up monitoring and physical assessment will be conducted 5 and 10 years after adoption of this plan. This will include the following activities and goals:

- **Streamwalks**
    - **Activities:**

        - The West Fork of Trail Creek will again be walked and the same stream reaches will be scored using the same system.
    - **Goals:**
        - **5-year:** All 10 reaches score at least Sub-Optimal (currently 6 of 10)
        - **10-year:** 5 reaches score Optimal (currently 2 of 10)
- **Water Quality Sampling**
    - **Activities:**
        - **Quarterly Monitoring:** Conduct quarterly grab sampling for parameters of concern including fecal coliform, nutrients (TN, NO_3, NH_4, TP, PO_4), and turbidity (for TSS).
        - **Delisting Sampling:** Conduct delisting sampling, four samples over a 30-day period, for fecal coliform as described in TMDL implementation plan for Trail Creek.
    - **Goals:**
        - **5-year:** 3percent reduction in TN and TP, and a 1 percent reduction in TSS
        - **10-year:** 6 percent reduction in TN and TP, and a 2 percent reduction in TSS
        - Delisting of Trail Creek from the 303(d) list for fecal coliform contamination.
- **Biological Monitoring**
    - **Activities:**
        - Macroinvertebrate analysis will be conducted at the current sampling locations and scored using the same system.
    - **Goals:**
        - **5-year:** Site TR1 will improve to a “fair” score and site TR3-WF will improve to a “good” score.
        - **10-year:** All sites will score either “good” or “excellent”.

Other measures will be tracked as well, including the number of BMPs implemented, the amount of impervious surface removed or replaced, the number of cisterns or other rainwater harvesting methods put in place, etc. At 5 years after adoption of this plan, mostly lower cost BMPs such as citizen education and an enhanced bacteria study should be completed, while funding sources are identified for the more expensive BMPs and programs.

4.6.2 Qualitative Evaluation Techniques

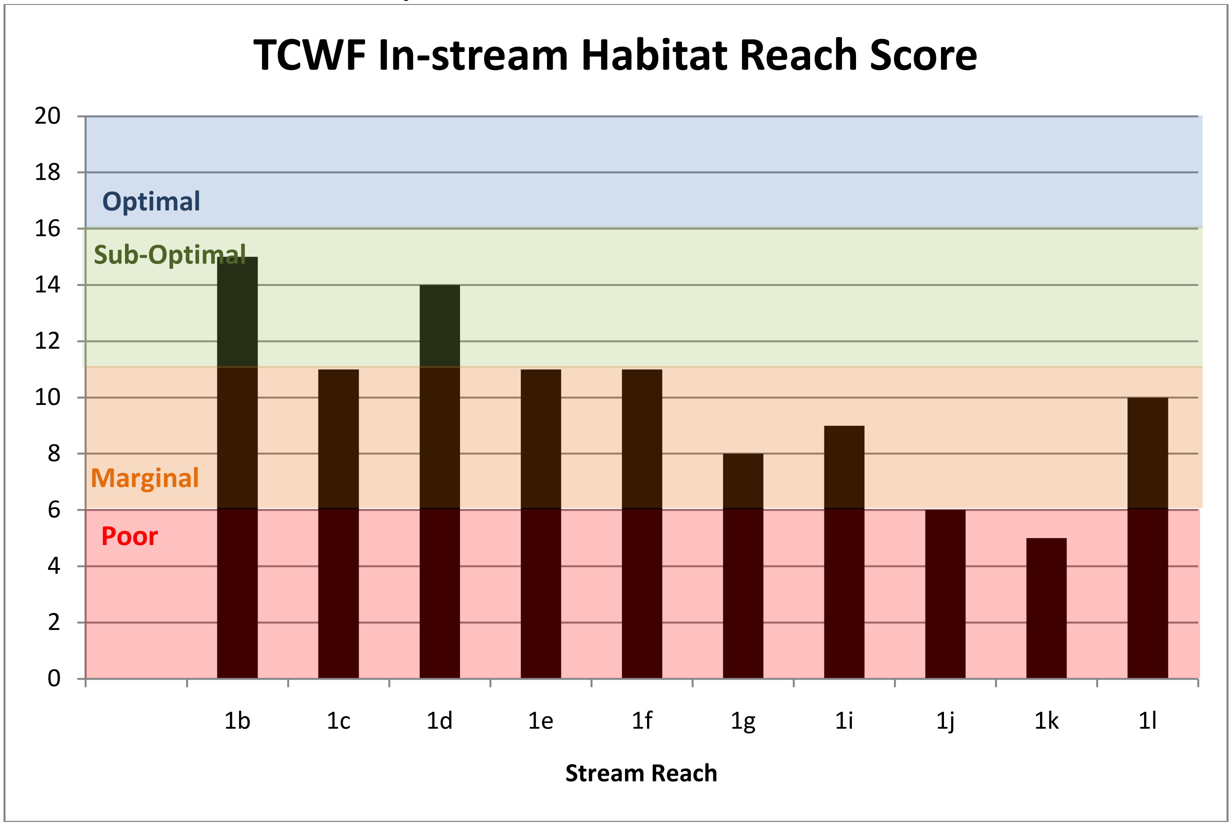
A set of qualitative evaluation criteria can be used to determine whether pollutant loading reductions are being achieved over time and whether substantial progress is being made towards attaining water quality standards in the watershed. Conversely, the criteria can be used for determining whether this Watershed Management Plan needs to be revised at a future time in order to meet standards. A summary (Table 4.6.2.1) of the methods provides an indication of how these programs might be measured and monitored to evaluate success in both the short and the long term. By evaluating the effectiveness of these programs, communities and agencies will be better informed about public response and success of the programs, how to improve the programs and which programs to continue. Although these methods of measuring progress are not tied directly to measurements in Trail Creek, it is fair to assume that the success of these actions and programs, collectively and over time, will impact positively on the instream conditions and measurements of the river system.

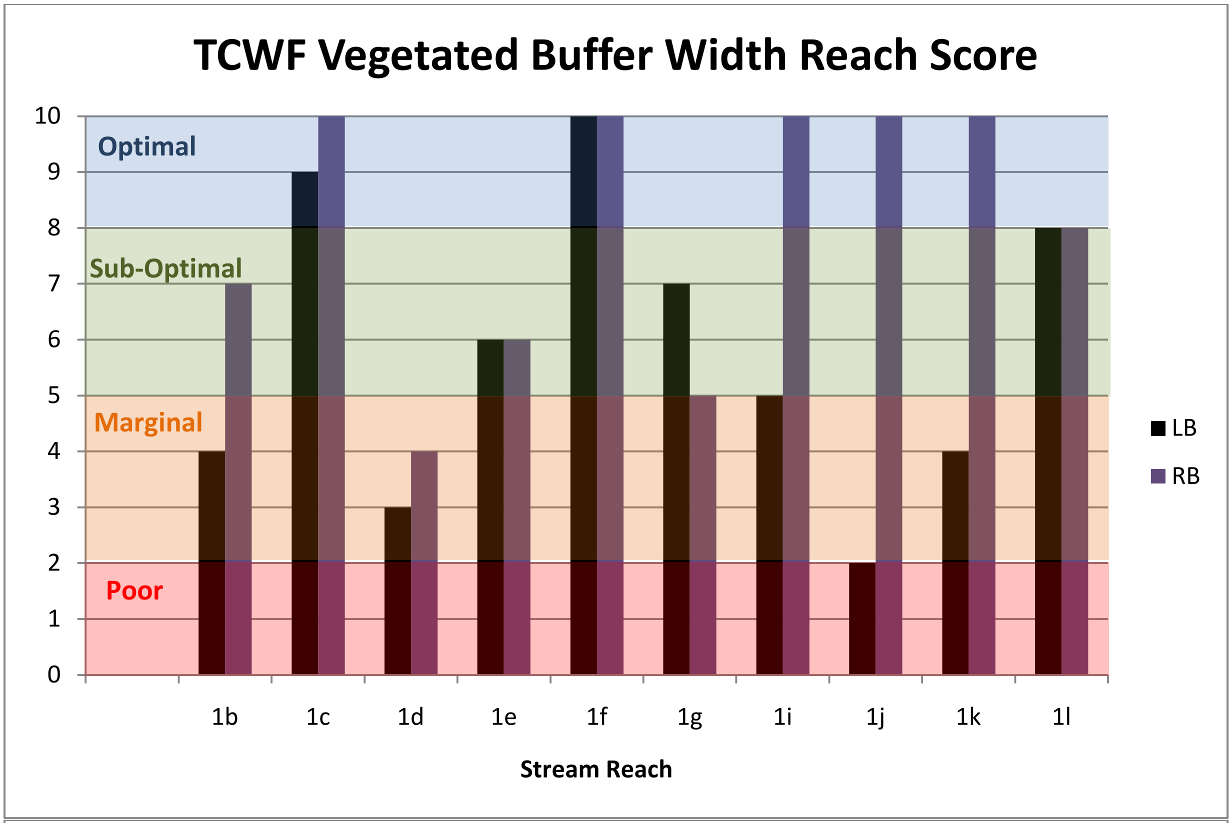
Table 4.6.2.1 *(Adapted from Lower Huron River Watershed Management Plan)*

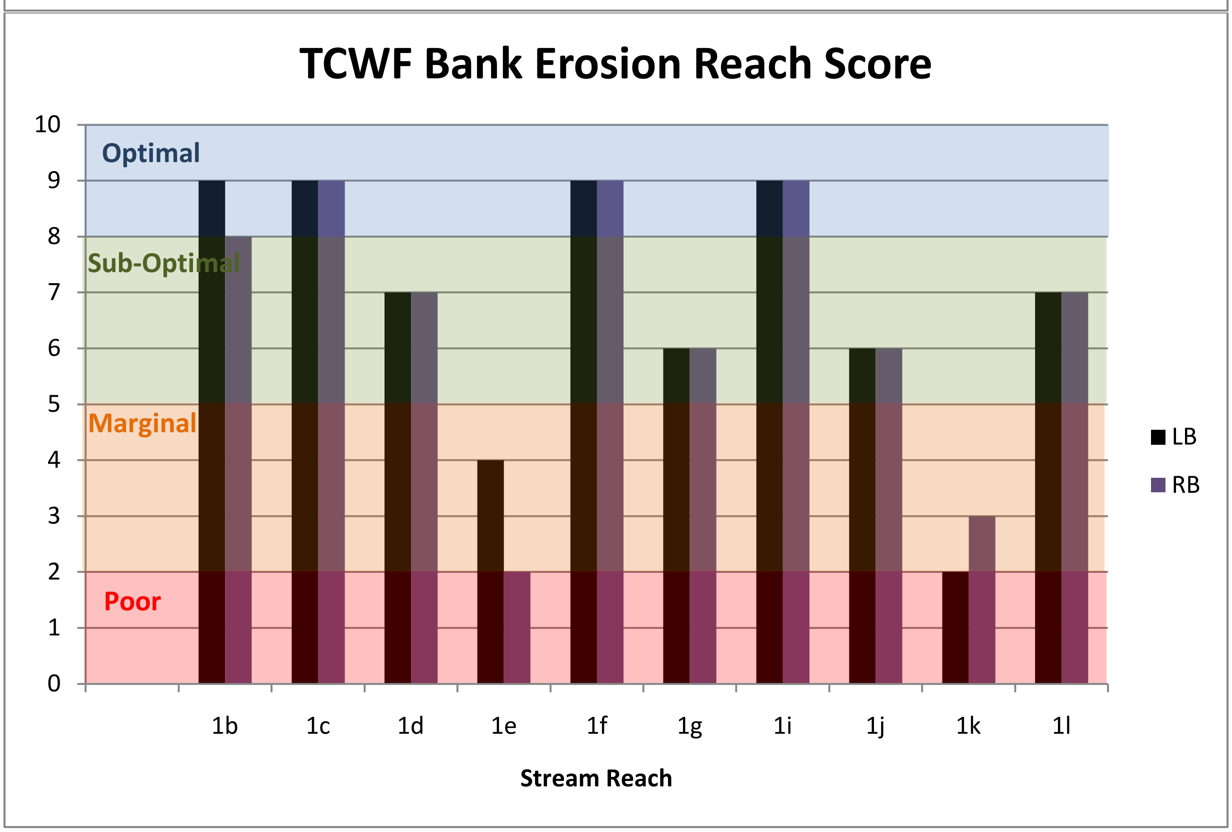
Evaluation Method	Program/Project	What is Measured	Pros and Cons	Implementation
Public Surveys	Public Education or involvement program/project	Awareness; Knowledge; Behaviors; Attitudes; Concerns	Moderate cost. Low response rate.	Pre- and post- surveys recommended. By mail, telephone, or group setting. Repetition on regular basis can show trends.
Written Evaluations	Public meeting or group education or involvement project	Awareness; Knowledge	Good response rate. Low cost	Post-event participants complete brief evaluations that ask what was learned, what was missing, what could be done better. Evaluations completed on-site.
Visual Documentation	Structural and vegetative BMP installations, retrofits	Aesthetics. Pre- and post- conditions.	Easy to implement. Low cost. Good, but limited form of communication.	Provides visual evidence. Photographs can be used in public communication materials.
Phone Call/ Complaint records (Stormwater Hotline)	Education efforts, advertising of contact number for complaints/ concerns	Number and types of concerns of public. Location of problem areas.	Subjective information from limited number of people.	Answer phone, letter, emails and track nature of calls and concerns
Participation Tracking	Public involvement and education projects	Number of people participating. Geographic distribution of participants. Amount of waste collected, e.g. stream cleanup waste collection	Low cost. Easy to track and understand.	Track participation by counting people, materials collected and having sign-in/ evaluation sheets.
Focus Groups	Information and education programs	Awareness; Knowledge; Perceptions; Behaviors	Medium to high cost to do well. Instant identification of motivators and barriers to behavior change.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion.

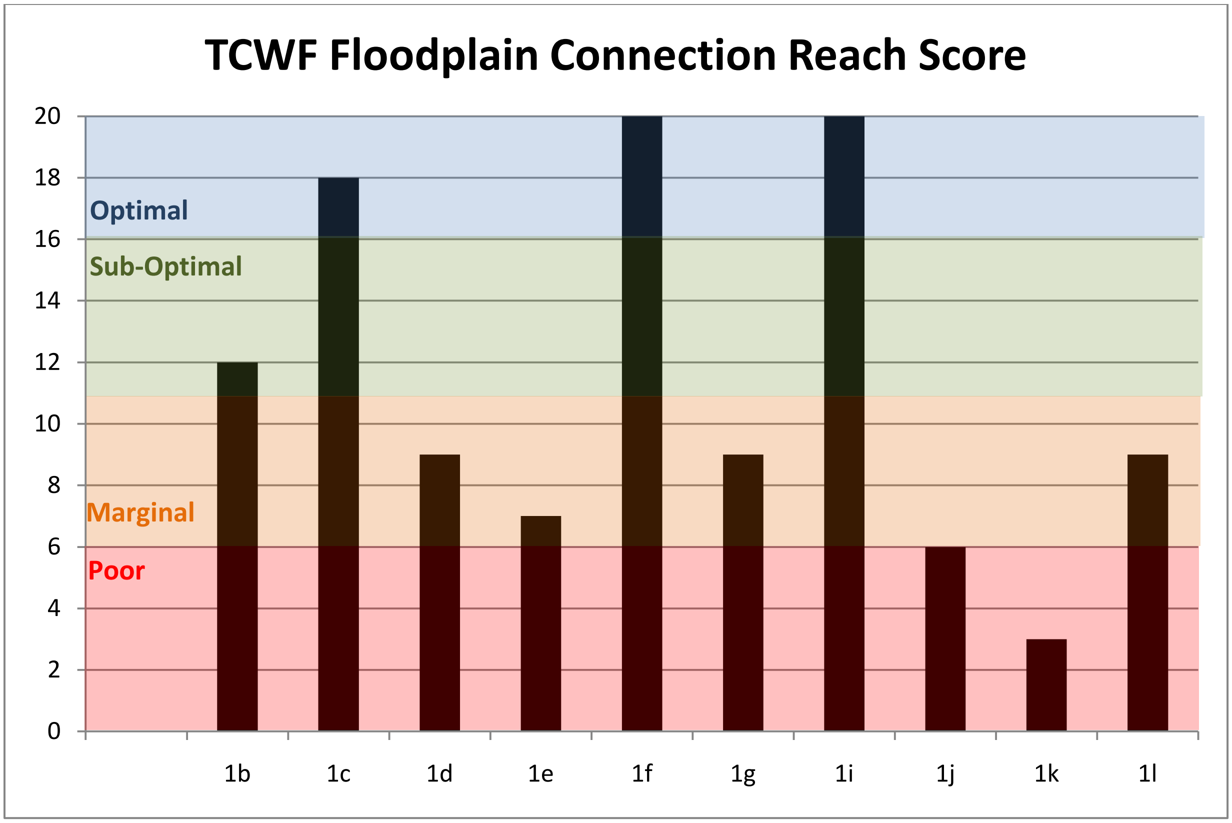
Appendix of Charts and Data

Section I – Stream Reach Scores by Parameter




TCWF Vegetated Buffer Width Reach Score
Optimal
Sub-Optimal
Marginal
Poor
0
1
2
3
4
5
6
7
8
9
10
1b
1c
1d
1e
1f
1g
1i
1j
1k
1l
Stream Reach
LB
RB


TCWF Bank Erosion Reach Score
Optimal
Sub-Optimal
Marginal
Poor
0
1
2
3
4
5
6
7
8
9
10
1b
1c
1d
1e
1f
1g
1i
1j
1k
1l
Stream Reach
LB
RB


TCWF Floodplain Connection Reach Score
Optimal
Sub-Optimal
Marginal
Poor
0
2
4
6
8
10
12
14
16
18
20
1b
1c
1d
1e
1f
1g
1i
1j
1k
1l

Section II – Water Quality Data

II.1 – Monthly Grab Sampling Results

NR = Non-recorded data (due to equipment failure or sampling methods were changed and therefore this data was not recorded)
ND = Non-detectable data (the amount was non-detectable by the sampling method)

Sample Site TR1

Date	Time	Weather	Temp (Deg. C)	pH	DO (mg/L)	Conductivity (mS/cm)
1/8/09	6:39 AM	Cloudy	9.44	7.33	8.80	0.054
2/5/09	6:25 AM	Clear	1.17	6.26	13.19	0.034
3/19/09	6:40 AM		12.16	7.17	9.37	0.057
4/14/09	6:25 AM	Light Rain	15.05	6.61	8.81	0.051
5/12/09	6:20 AM	Partly Cloudy	17.80	6.55	7.66	0.052
6/9/09	6:50 AM	Clear	21.65	6.91	6.01	0.083
7/1/09	6:45 AM	Partly Cloudy	21.68	6.71	5.95	0.079
8/4/09	6:32 AM	Clear, Dawn	23.91	6.21	4.66	0.095
9/1/09	6:37 AM	Overcast	21.28	7.15	6.21	0.090
9/29/09	6:40 AM	Clear, Windy	18.73	8.67	6.73	0.067
10/21/09	6:55 AM	Dark	12.58	7.69	8.82	0.254
11/18/09	6:31 AM	Cloudy, Drizzle	15.24	9.17	7.84	0.130
12/16/09	6:35 AM	Foggy, Clear, Windy	10.68	8.02	9.80	0.363
1/12/10	6:38 AM	Clear	3.46	5.37	11.60	0.283
2/10/10	6:30 AM	Clear, Windy	5.36	7.63	10.83	0.403
3/10/10	6:15 AM	Light Rain	11.94	8.32	9.14	0.099
4/7/10	6:30 AM	Clear	17.91	8.29	6.98	0.197
5/5/10	6:25 AM	Clear	19.21	8.76	6.89	0.275

Sample Site TR1 (cont'd)

Date	Fecal Coliform (#Col/100 mL)	TSS (mg/L)	BOD (mg/L)	Turbidity (NTU)	TOC (ppm)
1/8/09	146	15	1	26.9	9.31
2/5/09	90	9	1	6.3	6.02
3/19/09	134	9	2	9.6	12.34
4/14/09	311	12	1	16	6.11
5/12/09	496	12	2	16.1	10.71
6/9/09	154	22	1	30.4	11.87
7/1/09	347	6	ND	12.6	7.37
8/4/09	1980	25	1	21.5	8.39
9/1/09	1046	11	1	16.2	6.29
9/29/09	2420	12	ND	15.2	11.50
10/21/09	2420	10	ND	15.7	31.16
11/18/09	866	7	2	13.9	17.73
12/16/09	250	7	ND	15.7	4.21
1/12/10	345	3	ND	8.69	3.43
2/10/10	143	20	ND	28.6	3.43
3/10/10	687	12	ND	10.5	3.43
4/7/10	276	10	ND	15.0	3.64
5/5/10	186	35	2	39.2	7.52

Date	NH4	NO2 + NO3	TN	PO4	TP	Cu	Zn
1/8/09	NR	NR	NR	NR	NR	NR	NR
2/5/09	NR	NR	NR	NR	NR	NR	NR
3/19/09	NR	NR	NR	NR	NR	NR	NR
4/14/09	NR	NR	NR	NR	NR	NR	NR
5/12/09	NR	NR	NR	NR	NR	NR	NR
6/9/09	0.0534	0.1012	0.99126	ND	0.05886	NR	NR
7/1/09	0.05305	0.3552	0.60048	ND	ND	NR	NR
8/4/09	0.0785	0.2564	0.4995	0.0107	0.02898	NR	NR
9/1/09	0.0453	0.1357	0.387307	ND	0.017707	2.392	82.57
9/29/09	0.093	0.1412	0.70812	0.0093	0.05908	ND	59.71
10/21/09	0.168	0.1675	0.484036	ND	0.03542	3.928	62.26
11/18/09	0.0606	0.4123	0.77224	ND	ND	ND	26.58
12/16/09	0.1416	0.6149	0.866306	ND	0.035547	ND	64.08
1/12/10	0.0779	0.7269	0.94335	ND	0.010455	3.303	84.53
2/10/10	0.1667	0.5469	0.946889	0.0055	0.043267	5.117	172.5
3/10/10	0.0289	0.721	0.98672	0.0049	0.05584	ND	96.01
4/7/10						ND	29.43
5/5/10						6.323	136.6

Sample Site TR2-WF

Date	Time	Weather	Temp (Deg. C)	pH	DO (mg/L)	Conductivity (mS/cm)
1/8/09	7:02 AM		8.89	7.33	8.80	0.053
2/5/09	6:50 AM	Cold	2.46	6.02	12.67	0.035
3/19/09	6:58 AM		12.99	6.89	8.84	0.055
4/14/09	6:45 AM	Heavy Rain	15.43	6.61	9.10	0.048
5/12/09	6:45 AM		18.79	6.96	5.89	0.076
6/9/09	7:10 AM	Clear	22.08	6.62	7.00	0.076
7/1/09	7:05 AM	Partly Cloudy	22.02	6.67	5.68	0.095
8/4/09	6:50 AM	Clear	23.97	7.25	6.05	0.093
9/1/09	7:06 AM	Overcast	21.20	6.59	6.74	0.103
9/29/09	7:00 AM	Dawn, Windy	19.00	7.70	7.56	0.073
10/20/09	7:15 AM	Clear	12.99	6.99	9.25	0.128
11/18/09	6:58 AM	Cloudy, Drizzle	15.34	7.38	8.65	0.142
12/16/09	6:56 AM	Clear, Windy	9.60	6.67	9.97	0.323
1/13/10	6:50 AM	Clear	3.56	8.02	3.84	0.225
2/10/10	6:50 AM	Clear, Windy	4.97	6.47	11.15	0.416
3/10/10	6:35 AM	In Between Showers	11.46	7.61	8.96	0.119
4/7/10	6:50 AM	Clear	17.01	6.95	7.81	0.128
5/5/10	6:40 AM	Clear	19.61	6.73	7.83	0.249

Date	Fecal Coliform (#Col/100 mL)	TSS (mg/L)	BOD (mg/L)	Turbidity (NTU)	TOC (ppm)
1/8/09	287	ND	ND	19.4	10.07
2/5/09	69	19	1	14.6	8.35
3/19/09	103	7	2	9.5	5.88
4/14/09	386	12	1	15.3	6.76
5/12/09	81	15	2	20.1	8.87
6/9/09	39	9	1	17.6	10.34
7/1/09	169	10	1	18	9.74
8/4/09	78	8	1	11.9	9.26
9/1/09	153	7	1	14.2	7.11
9/29/09	201	10	ND	16.6	12.02
10/20/09	388	9	1	16	11.34
11/18/09	613	7	2	16.1	8.46
12/16/09	55	6	ND	14.6	4.40
1/13/10	204	7	ND	8.9	2.67
2/10/10	54	33	ND	39.3	13.42
3/10/10	248	10	ND	9.32	3.58
4/7/10	285	16	ND	15.3	4.77
5/5/10	1120	35	2	51.1	8.21

Sample Site TR2-WF (cont'd.)

Date	NH4	NO2 + NO3	TN	PO4	TP	Cu	Zn
1/8/09	NR	NR	NR	NR	NR	NR	NR
2/5/09	NR	NR	NR	NR	NR	NR	NR
3/19/09	NR	NR	NR	NR	NR	NR	NR
4/14/09	NR	NR	NR	NR	NR	NR	NR
5/12/09	NR	NR	NR	NR	NR	NR	NR
6/9/09	0.123	0.0939	0.70848	ND	0.09036	NR	NR
7/1/09	0.139	0.1976	0.63324	ND	ND	NR	NR
8/4/09	0.123	0.1949	0.42462	ND	0.00882	NR	NR
9/1/09	0.118	0.1608	0.474027	ND	0.028107	ND	57.41
9/29/09	0.122	0.2014	0.89586	0.0104	0.04648	ND	44.61
10/20/09	0.188	0.3807	0.645876	ND	0.02198	2.08	45.15
11/18/09	0.118	0.3097	0.97328	ND	0.00434	8.496	30.26
12/16/09	0.244	0.5382	0.9033	ND	0.038603	ND	81.82
1/13/10	0.1	0.3944	0.978897	ND	0.015441	3.351	71.84
2/10/10	0.273	0.4472	0.997554	0.0116	0.045197	ND	35.11
3/10/10	0.12	0.6601	1.0304	0.0032	0.05792	ND	93.09
4/7/10						ND	49.07
5/5/10						8.546	89.6

Sample Site TR3-WF

Date	Time	Weather	Temp (Deg. C)	pH	DO (mg/L)	Conductivity (mS/cm)
1/8/09	7:30 AM	Cloudy	8.33	6.55	9.87	0.053
2/5/09	7:05 AM	Cold	0.68	6.00	13.20	0.032
3/19/09	7:15 AM	Clear	10.72	6.48	9.43	0.052
4/14/09	6:55 AM	Drizzle	15.35	6.81	8.85	0.044
5/12/09	6:55 AM		17.60	6.89	7.62	0.065
6/9/09	7:25 AM	Clear	21.13	6.95	5.56	0.080
7/1/09	7:20 AM	Partly Cloudy	20.03	6.78	6.31	0.077
8/4/09	7:00 AM	Clear	22.05	7.29	5.94	0.092
9/1/09	7:22 AM	Overcast	20.64	6.65	6.86	0.101
9/29/09	7:20 AM	Clear, Windy	18.41	7.45	6.41	0.068
10/21/09	7:30 AM	Clear	12.67	6.74	9.14	0.084
11/18/09	7:11 AM	Cloudy, Drizzle	15.44	7.11	7.50	0.135
12/16/09	7:09 AM	Clear, Cold, Windy	9.03	6.79	9.23	0.253
1/13/10	7:12 AM	Clear	3.32	5.47	14.18	0.182
2/10/10	7:05 AM	Clear, Windy	5.03	5.89	10.94	0.136
3/10/10	6:45 AM	Light Rain	11.51	7.19	9.08	0.103
4/7/10	7:05 AM	Clear	16.09	5.86	5.90	0.113
5/5/10	6:50 AM	Clear	19.80	6.74	7.22	0.187

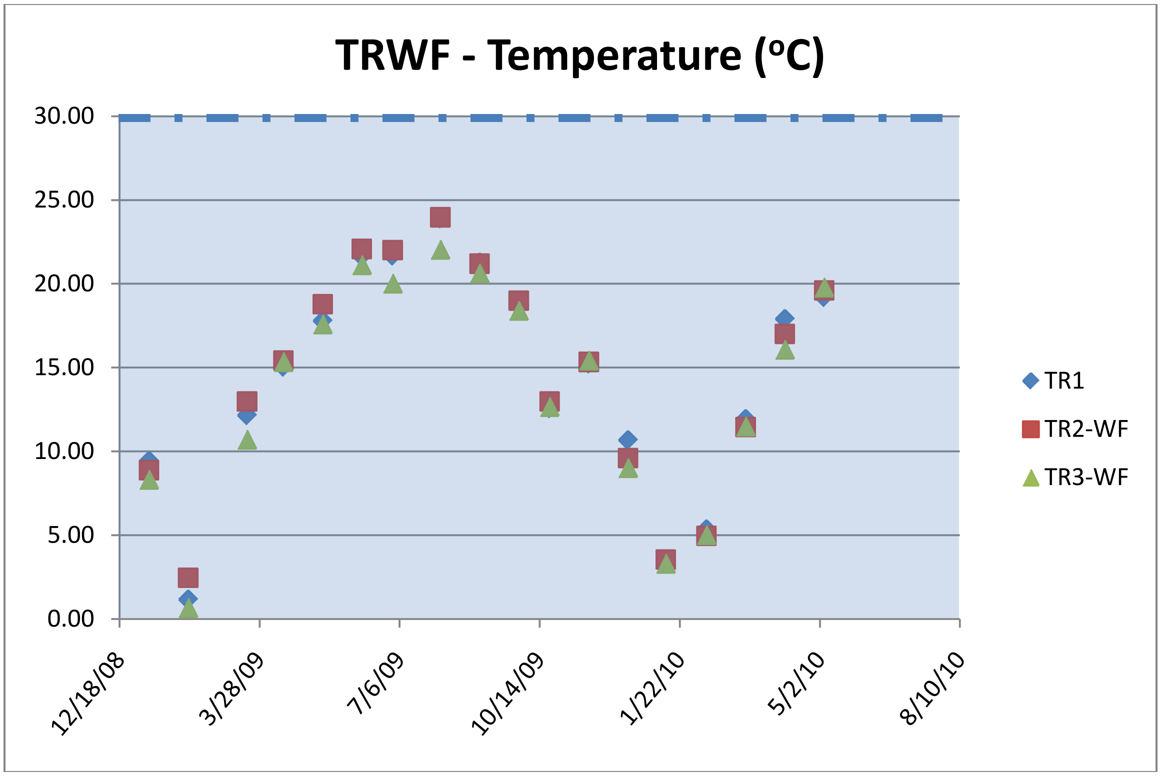
Date	Fecal Coliform (#Col/100 mL)	TSS (mg/L)	BOD (mg/L)	Turbidity (NTU)	TOC (ppm)
1/6/09	260	11	2	20	9.91
2/3/09	300	9	1	9.1	7.47
3/17/09	178	8	2	15.1	5.82
4/6/09	575	14	1	16	6.29
5/4/09	249	13	3	20	8.63
6/1/09	231	9	1	18.5	9.80
6/29/09	1298	15	ND	18.2	6.35
7/27/09	163	9	ND	17.7	8.96
8/24/09	1986	8	1	16.6	7.12
9/21/09	276	13	ND	19.7	12.22
10/19/09	261	13	1	19.8	8.06
11/16/09	275	46	2	19.8	6.67
12/14/09	64	19	ND	33.6	4.26
1/11/10	115	15	ND	15.6	2.83
2/8/10	72	26	ND	42.1	4.08
3/8/10	45	10	ND	9.39	3.61
4/5/10	345	14	ND	14.4	3.93
5/6/10	1046	40	3	52.3	7.86

Sample Site TR3-WF (cont'd.)

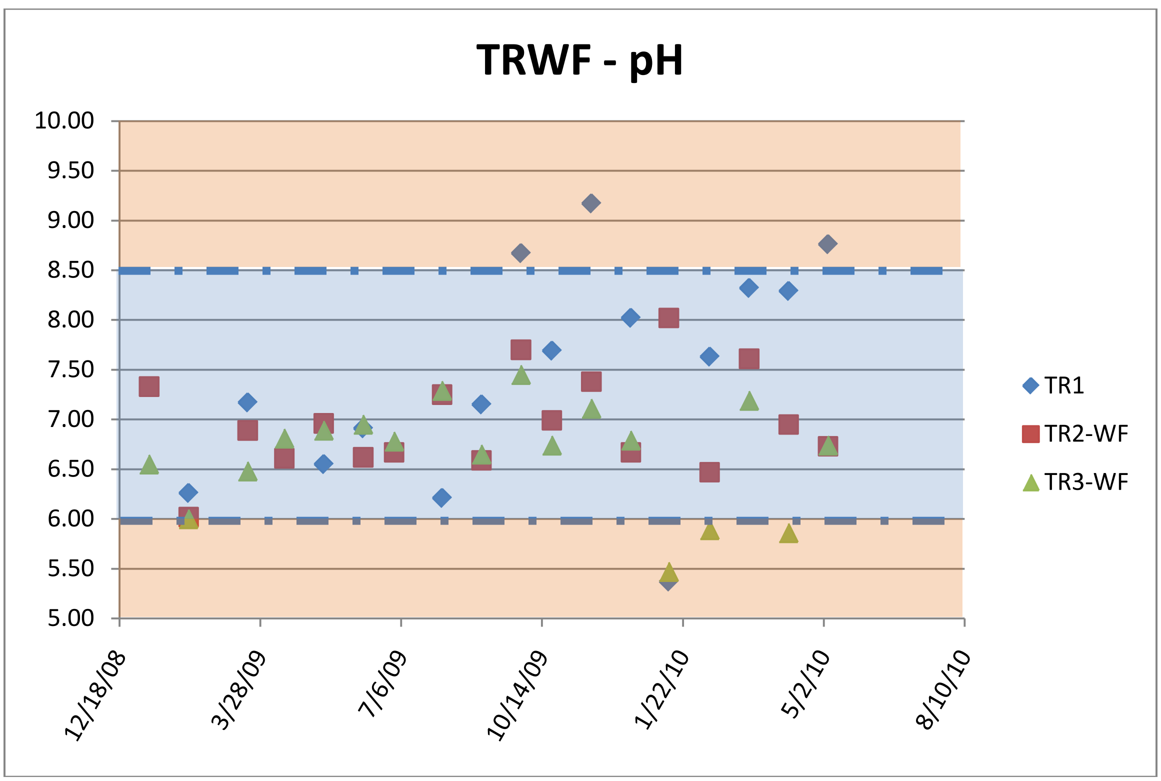
Date	NH4	NO2 + NO3	TN	PO4	TP	Cu	Zn
1/6/09	NR	NR	NR	NR	NR	NR	NR
2/3/09	NR	NR	NR	NR	NR	NR	NR
3/17/09	NR	NR	NR	NR	NR	NR	NR
4/6/09	NR	NR	NR	NR	NR	NR	NR
5/4/09	NR	NR	NR	NR	NR	NR	NR
6/1/09	0.176	0.2426	0.64602	ND	0.06498	NR	NR
6/29/09	0.064	0.6225	0.87498	ND	ND	NR	NR
7/27/09	0.059	0.5211	0.65772	0.0115	0.0445	NR	NR
8/24/09	0.085	0.2148	0.544747	ND	0.019787	ND	54.74
9/21/09	0.123	0.2308	0.91686	0.0106	0.04368	ND	53.89
10/19/09	0.315	0.1285	0.584136	ND	0.02422	4.166	94.91
11/16/09	0.181	0.2837	0.6538	ND	0.00378	8.619	43.56
12/14/09	0.25	0.486	1.024094	ND	0.039568	ND	27.23
1/11/10	0.131	0.5497	1.07106	0.0022	0.025574	ND	100.7
2/8/10	0.289	0.4537	1.046129	0.0108	0.052274	6.846	27.31
3/8/10	0.115	0.7283	1.23728	0.0034	0.06096	ND	48.41
4/5/10						ND	36.31
5/6/10						9.475	99.92

Grab Sampling Results Graphically Represented by Indicator. Spaces in the data represent either there was no data available or data was below detection limits. Shading is explained below.

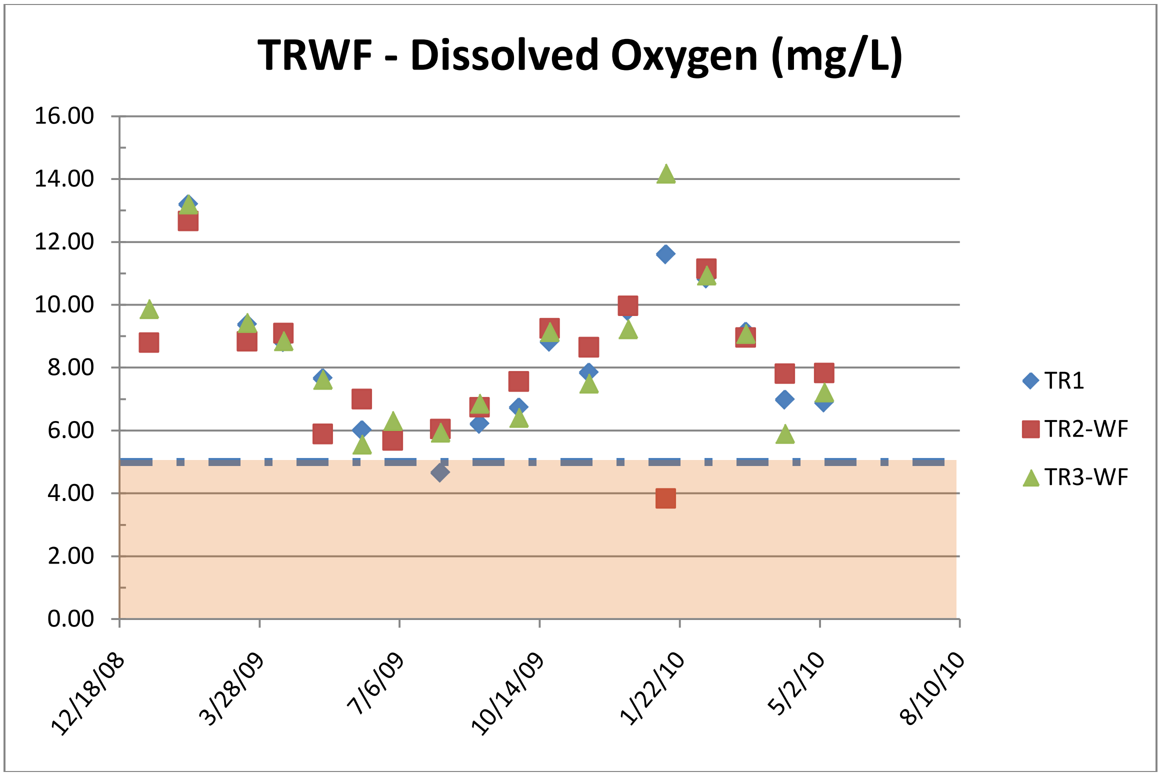
	= Optimal		= Acceptable		= Level of Concern

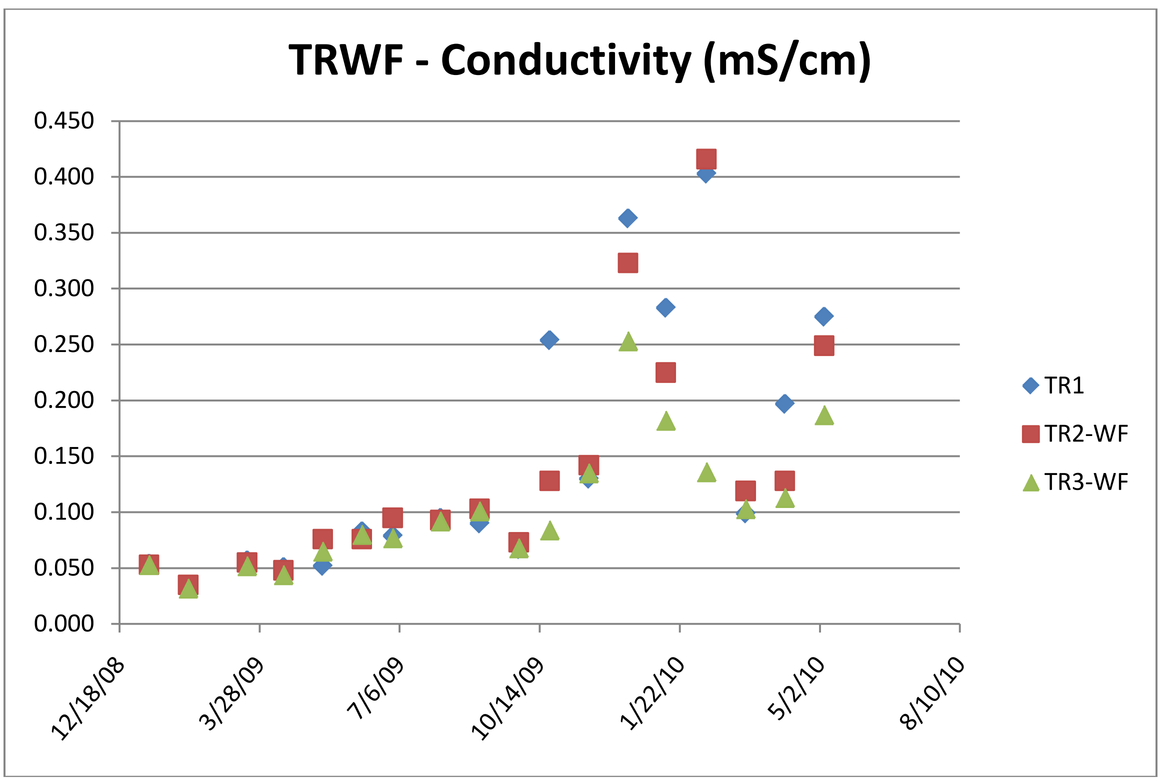


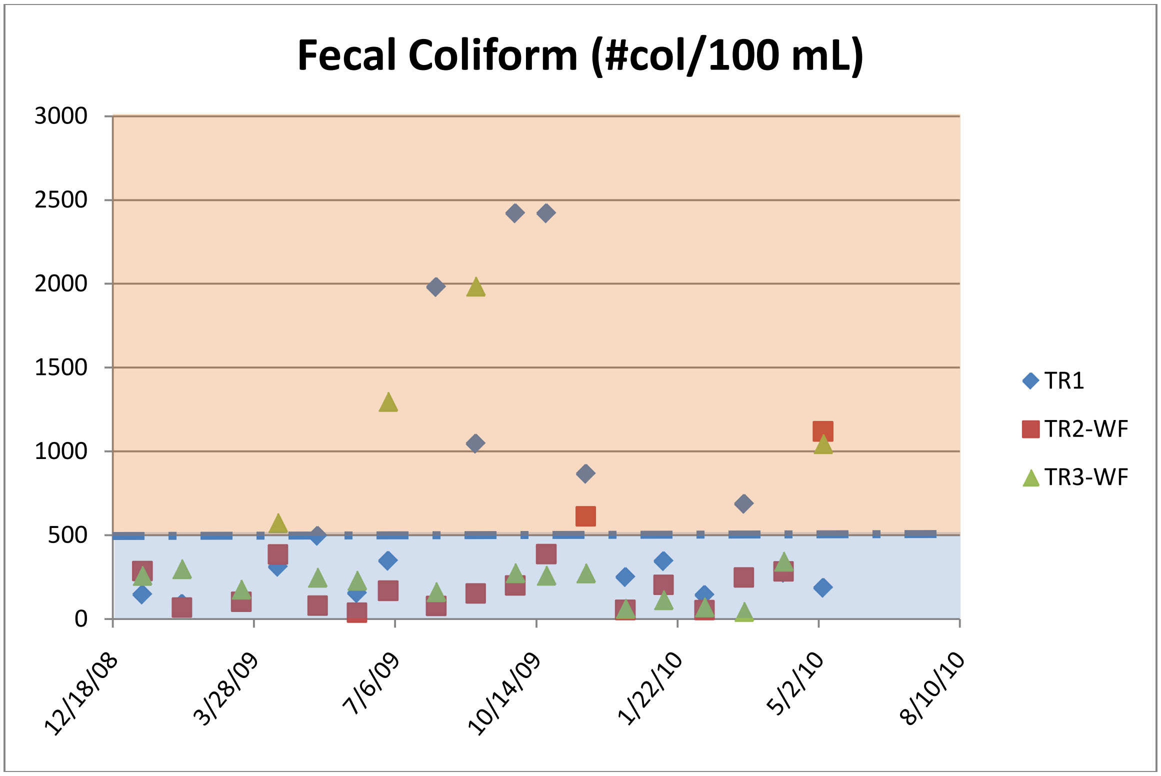
TRWF - Temperature (oC)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

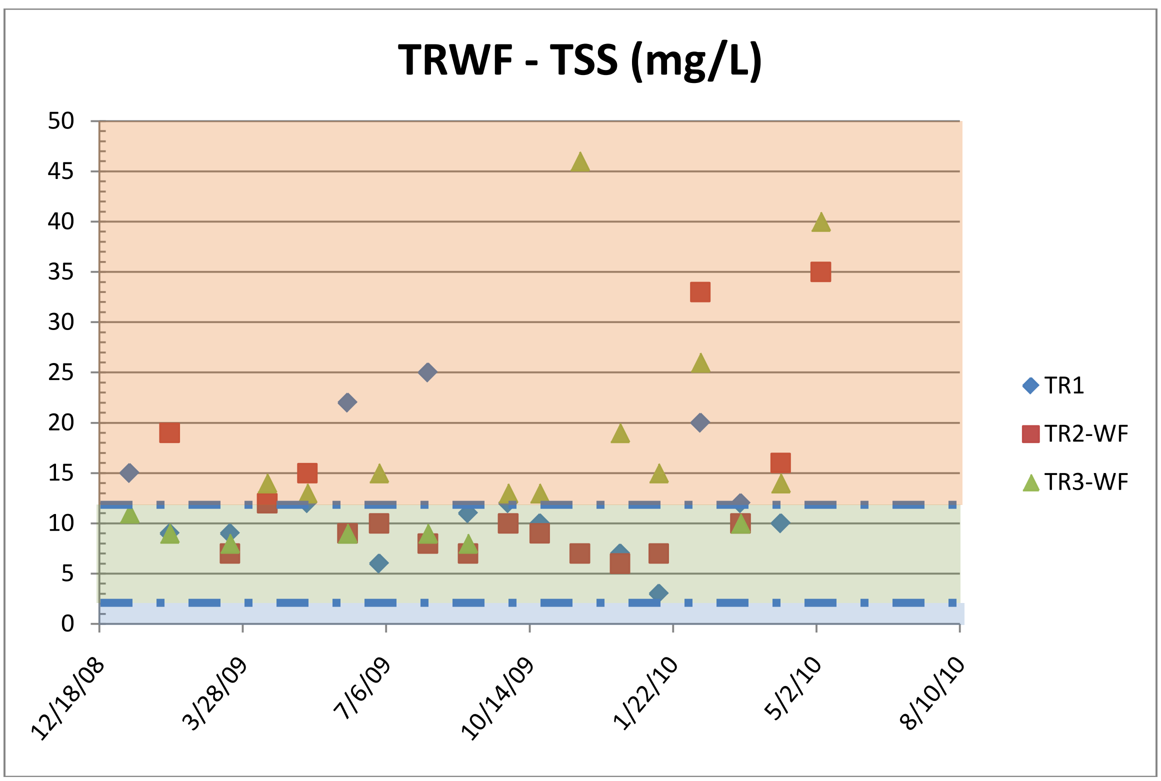


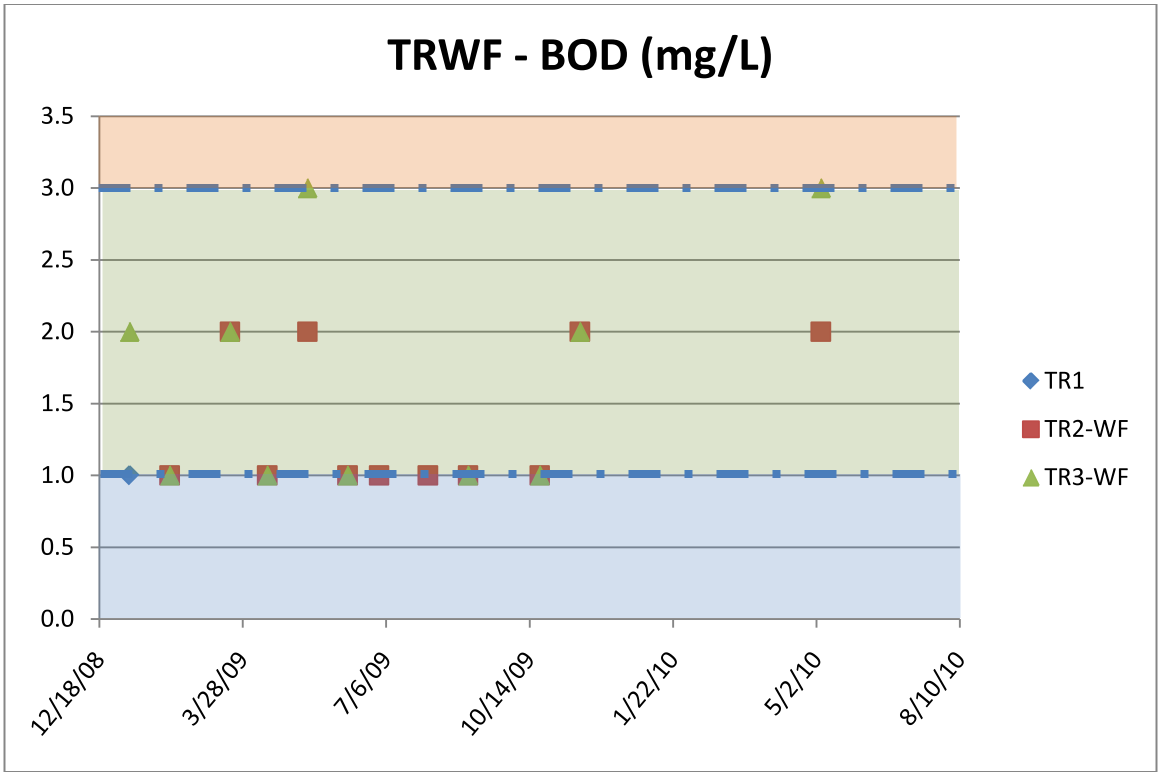
TRWF - pH
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

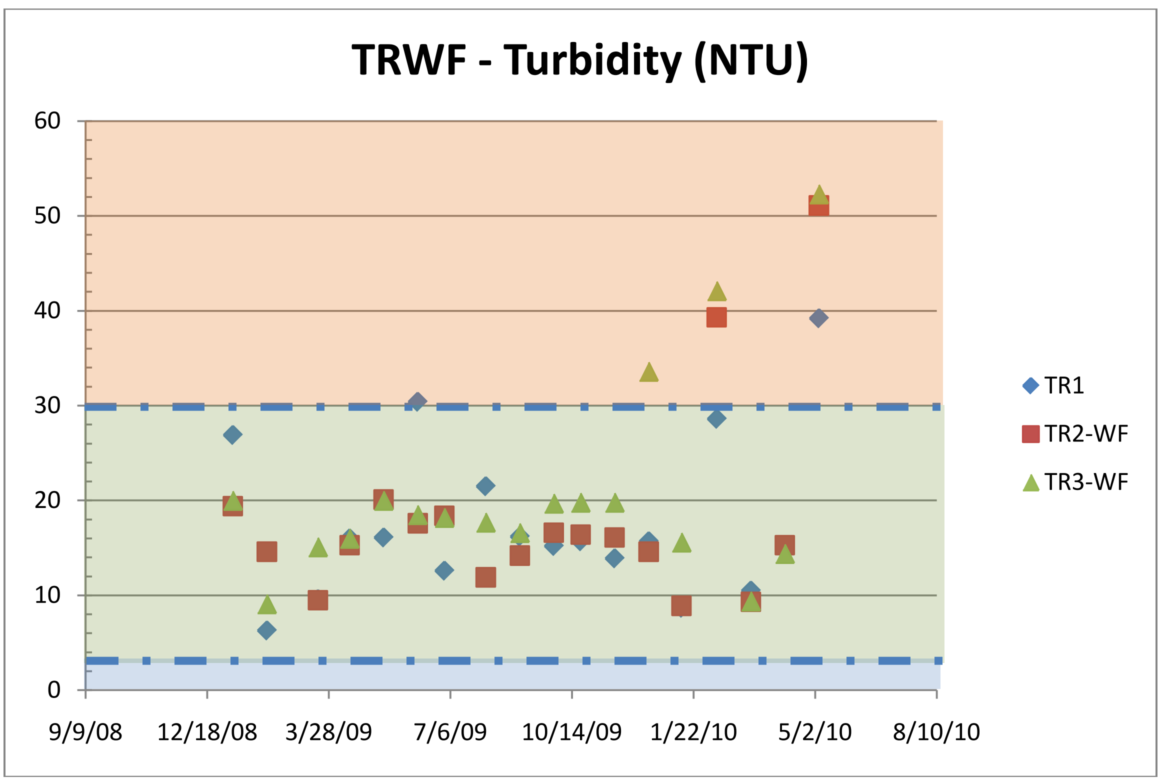

TRWF - Dissolved Oxygen (mg/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

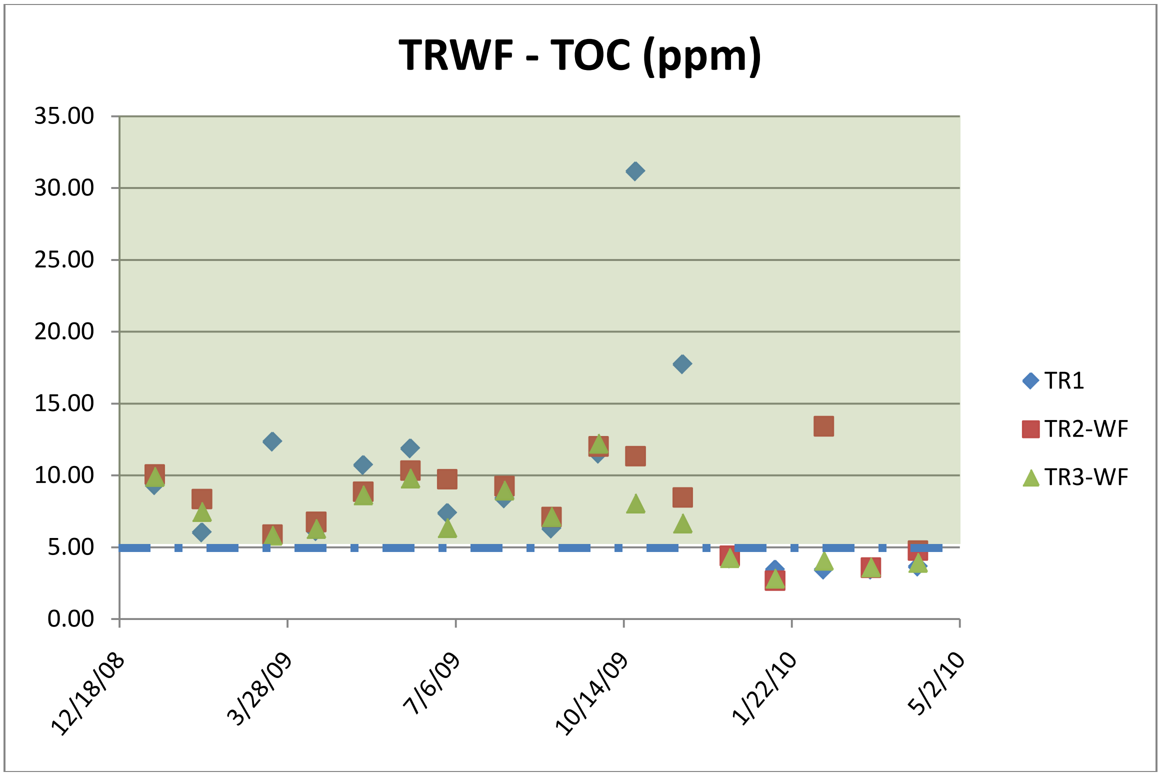

TRWF - Conductivity (mS/cm)
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

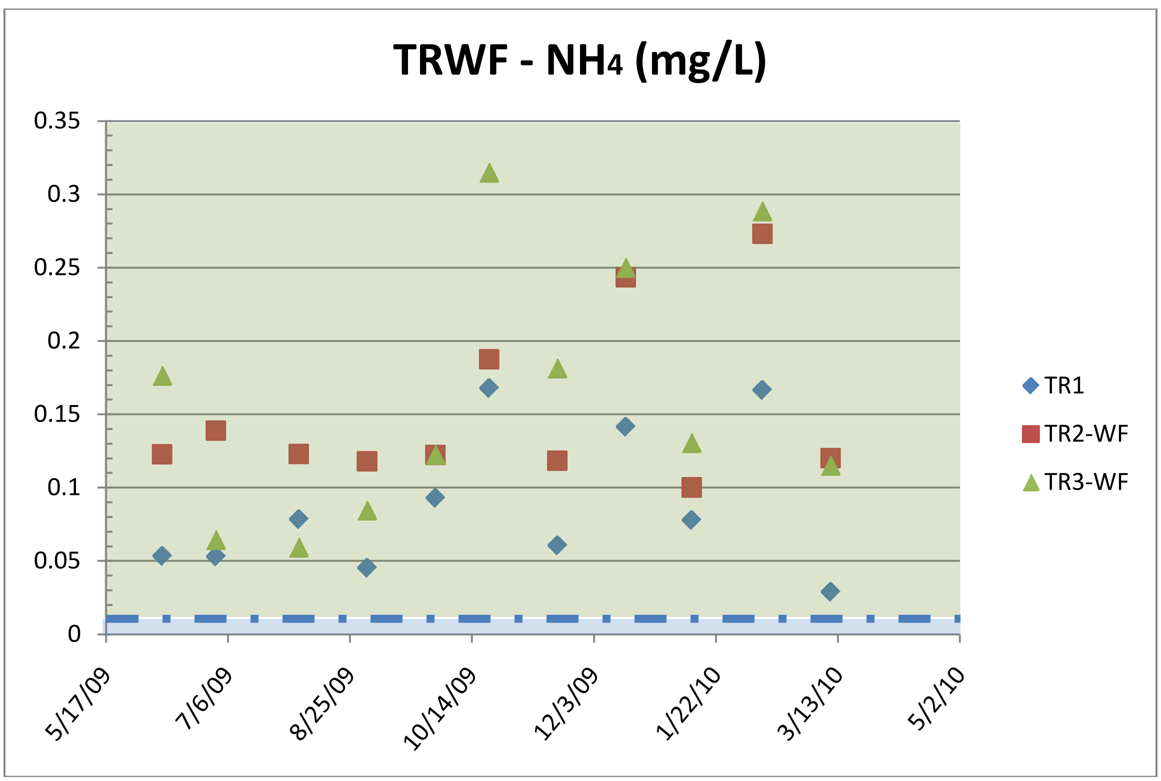

Fecal Coliform (#col/100 mL)
3000
2500
2000
1500
1000
500
0
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

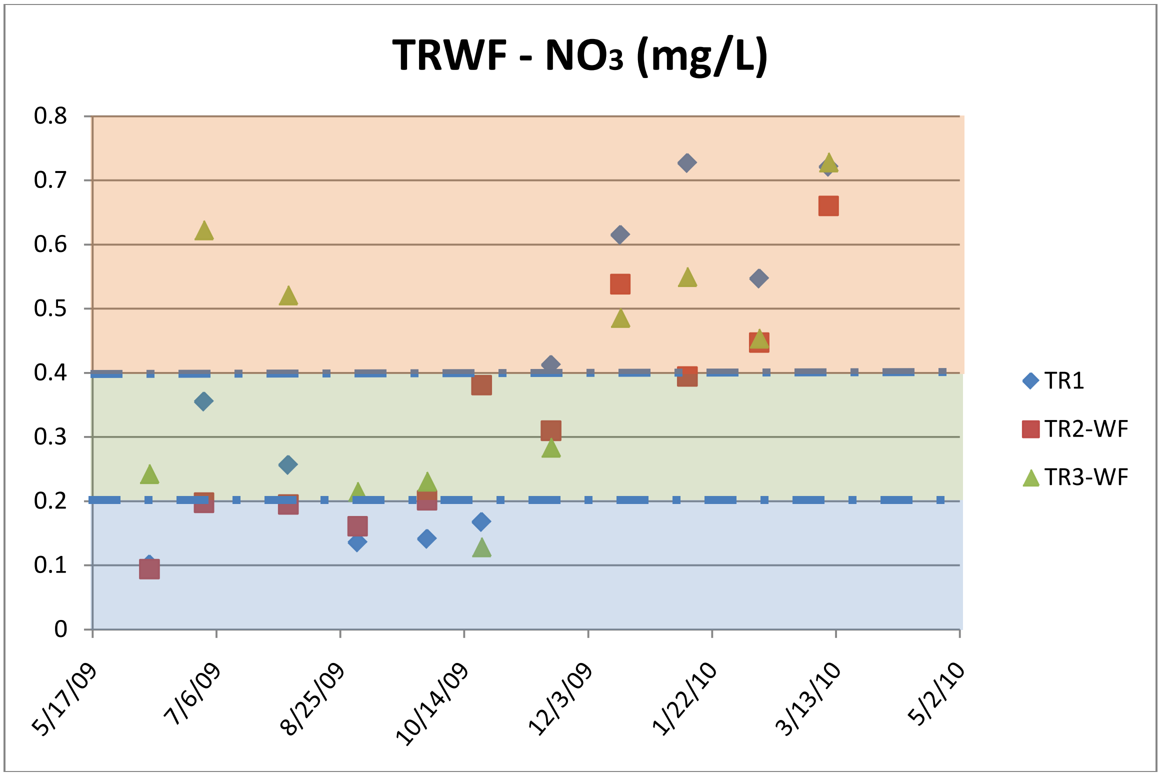

TRWF - TSS (mg/L)
50
45
40
35
30
25
20
15
10
5
0
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

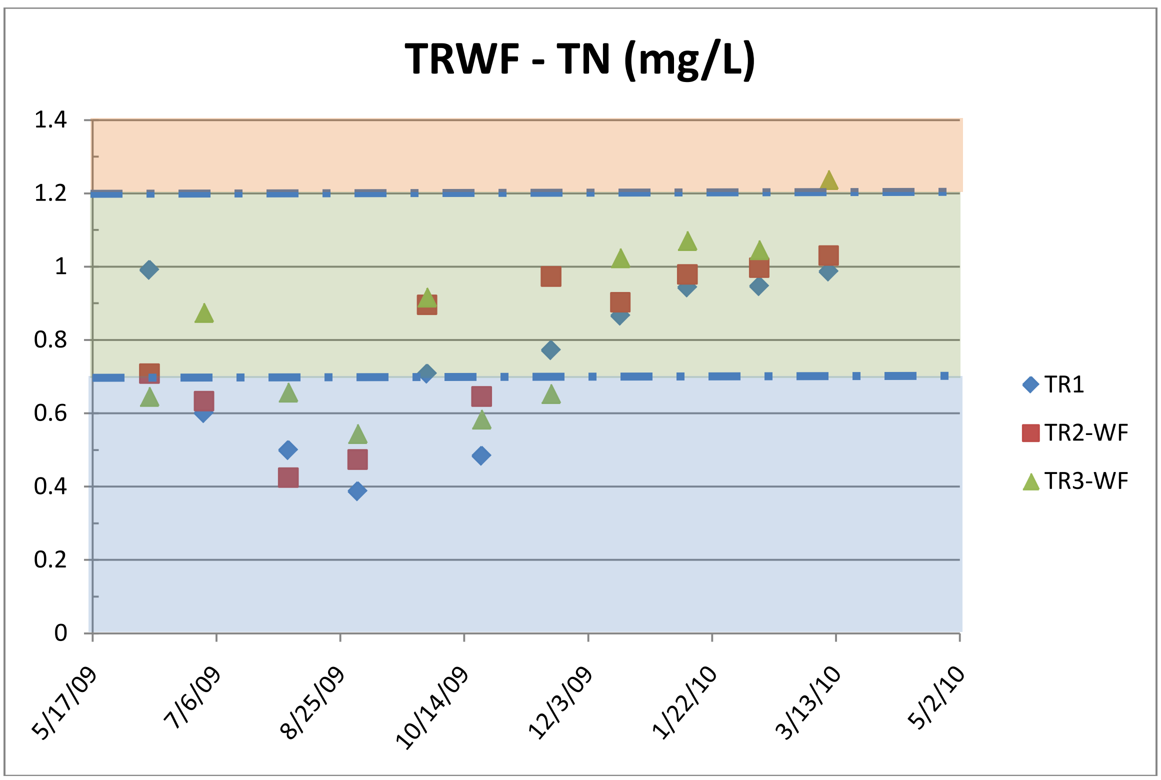

TRWF - BOD (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

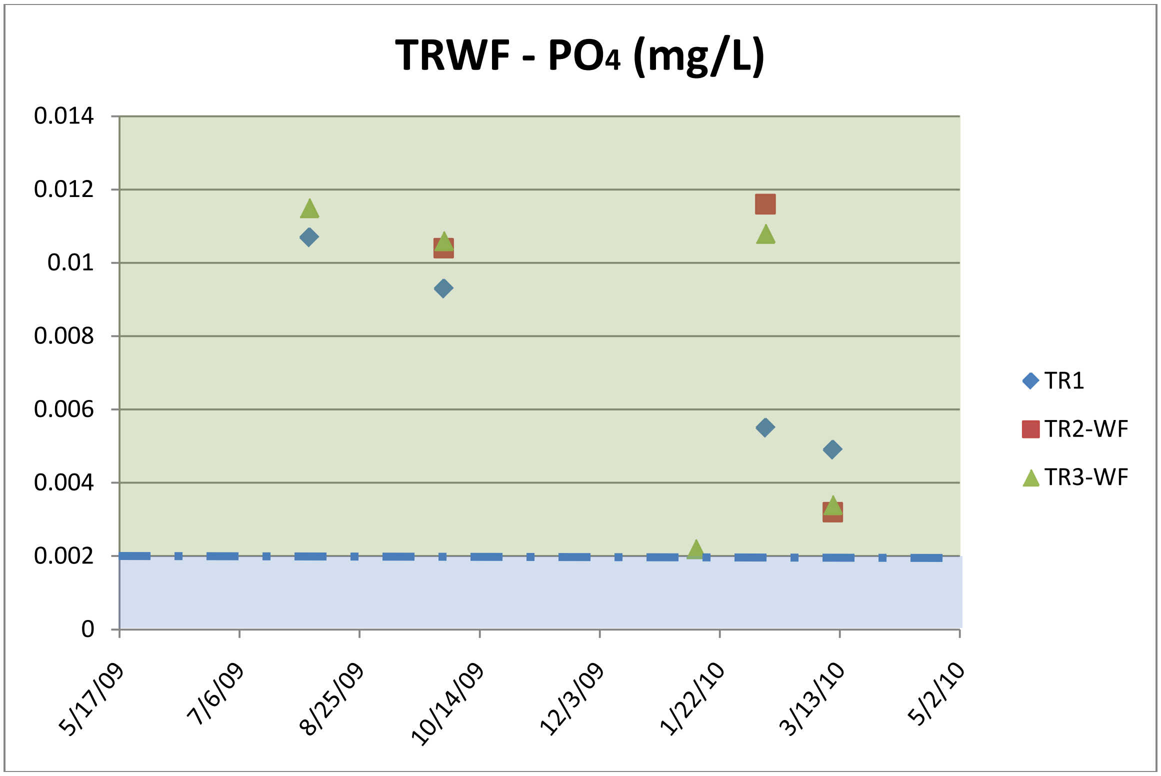

TRWF - Turbidity (NTU)
60
50
40
30
20
10
0
9/9/08
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
8/10/10
TR1
TR2-WF
TR3-WF

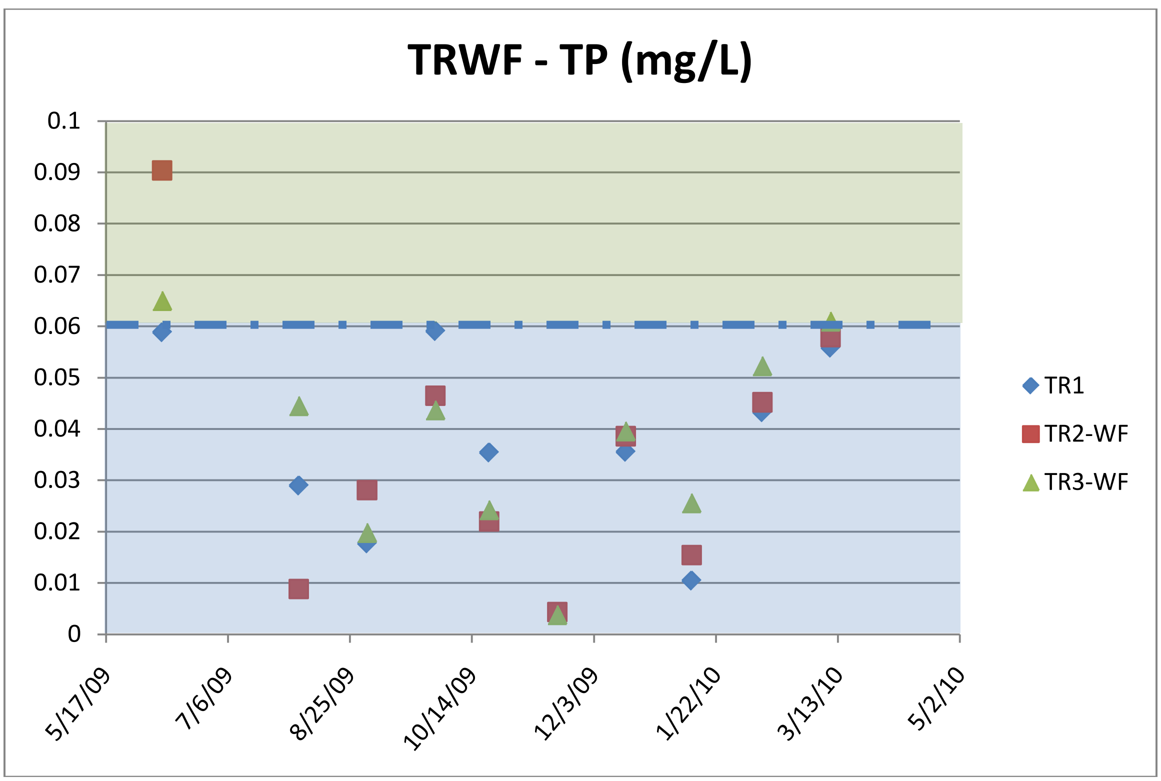

TRWF - TOC (ppm)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12/18/08
3/28/09
7/6/09
10/14/09
1/22/10
5/2/10
TR1
TR2-WF
TR3-WF

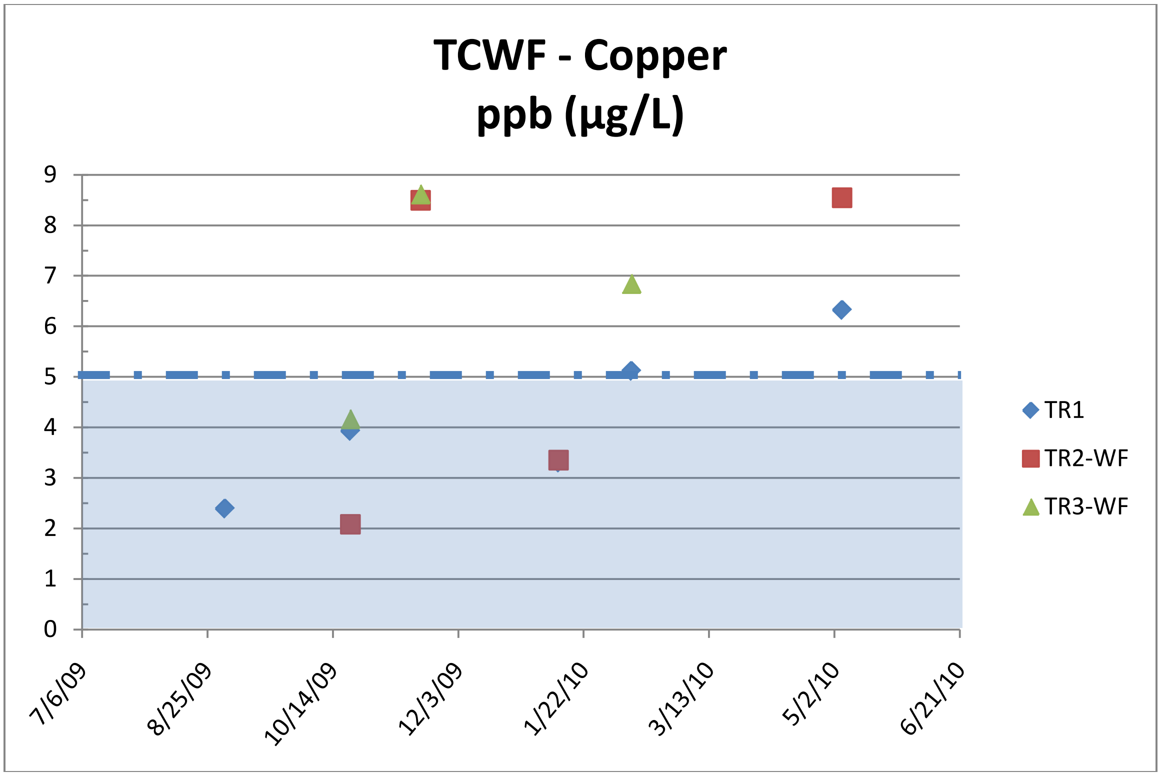

TRWF - NH4 (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/17/09
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
TR1
TR2-WF
TR3-WF

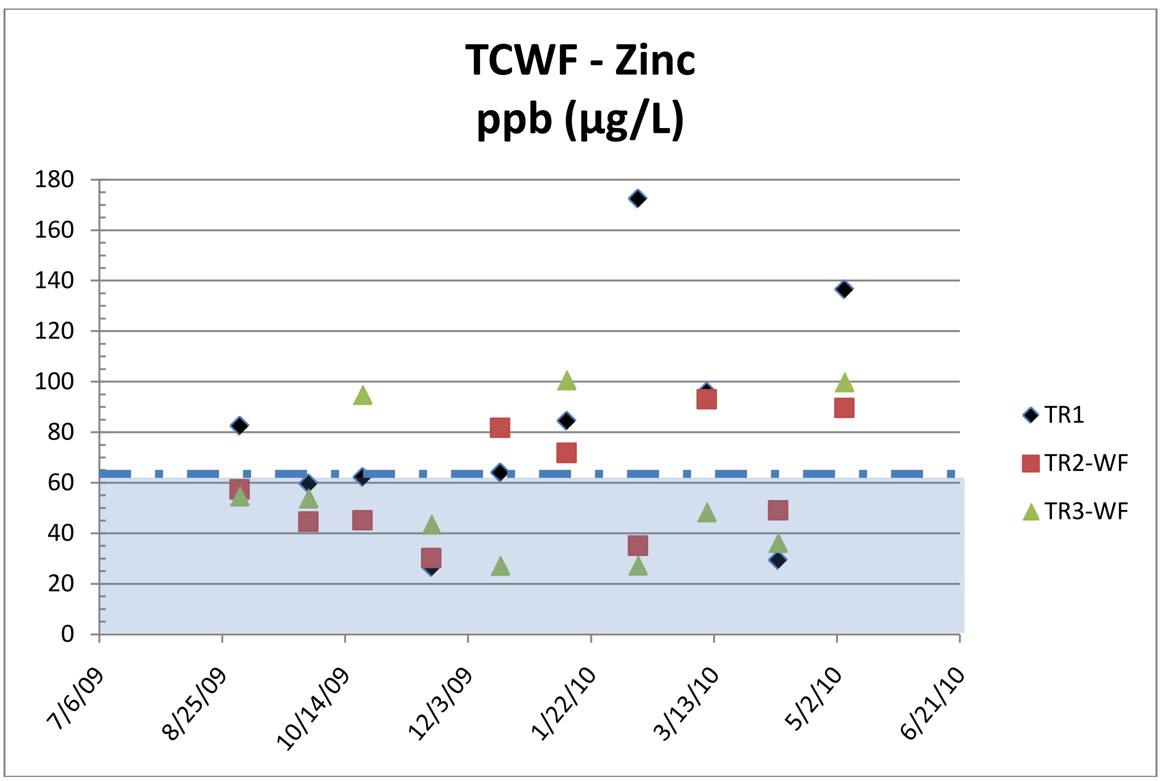

TRWF - NO3 (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5/17/09
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
TR1
TR2-WF
TR3-WF


TRWF - TN (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/17/09
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
TR1
TR2-WF
TR3-WF


TRWF - PO4 (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
5/17/09
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
TR1
TR2-WF
TR3-WF


TRWF - TP (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5/17/09
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
TR1
TR2-WF
TR3-WF

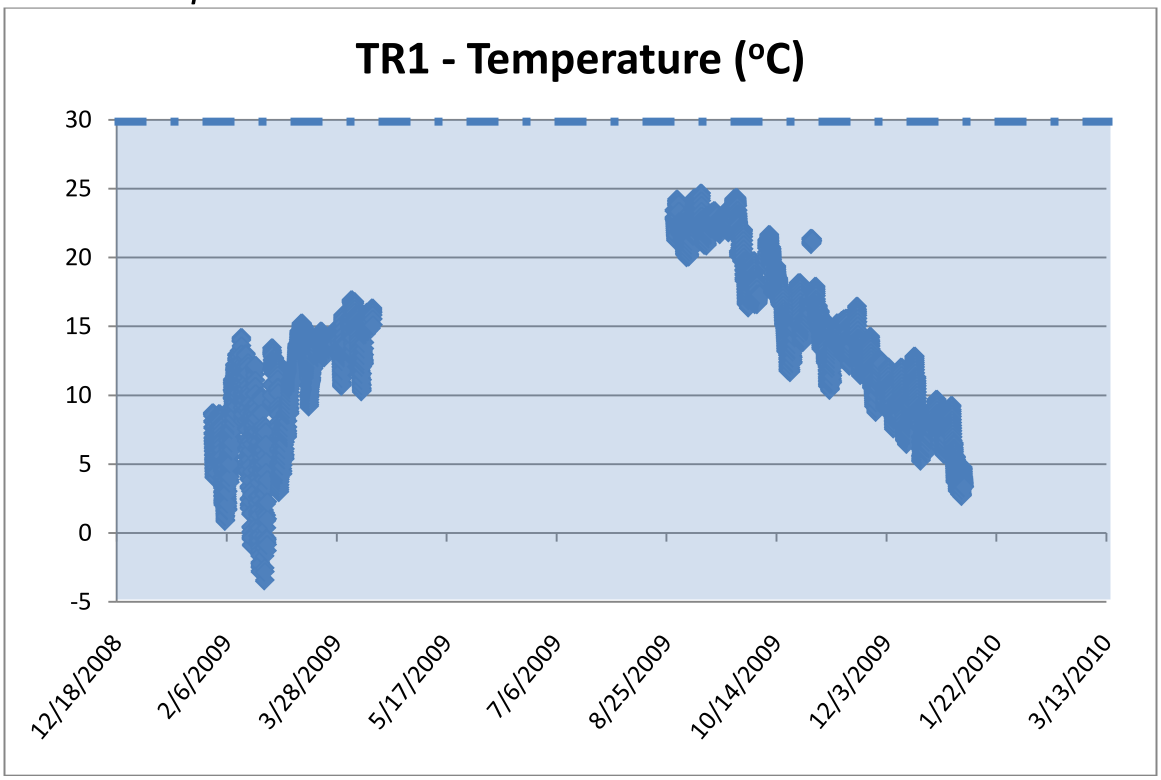

TCWF - Copper
ppb (µg/L)
9
8
7
6
5
4
3
2
1
0
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
6/21/10
TR1
TR2-WF
TR3-WF

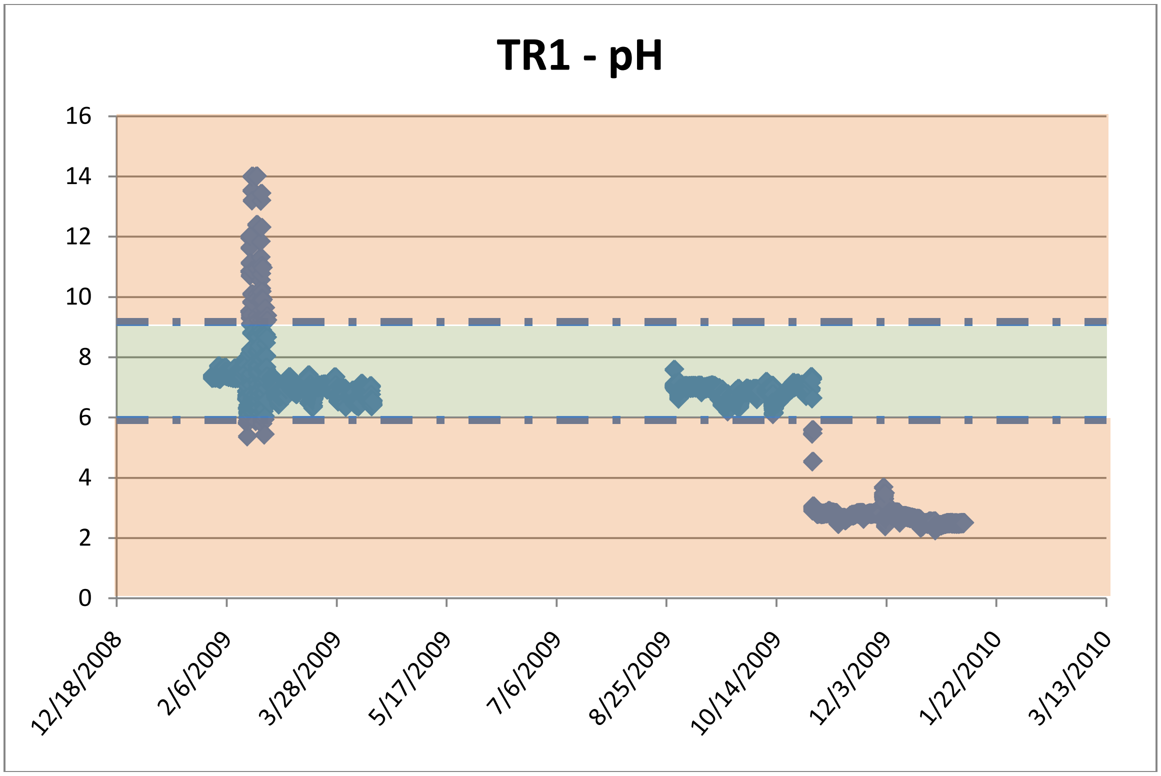

TCWF - Zinc
ppb (µg/L)
180
160
140
120
100
80
60
40
20
0
7/6/09
8/25/09
10/14/09
12/3/09
1/22/10
3/13/10
5/2/10
6/21/10
TR1
TR2-WF
TR3-WF

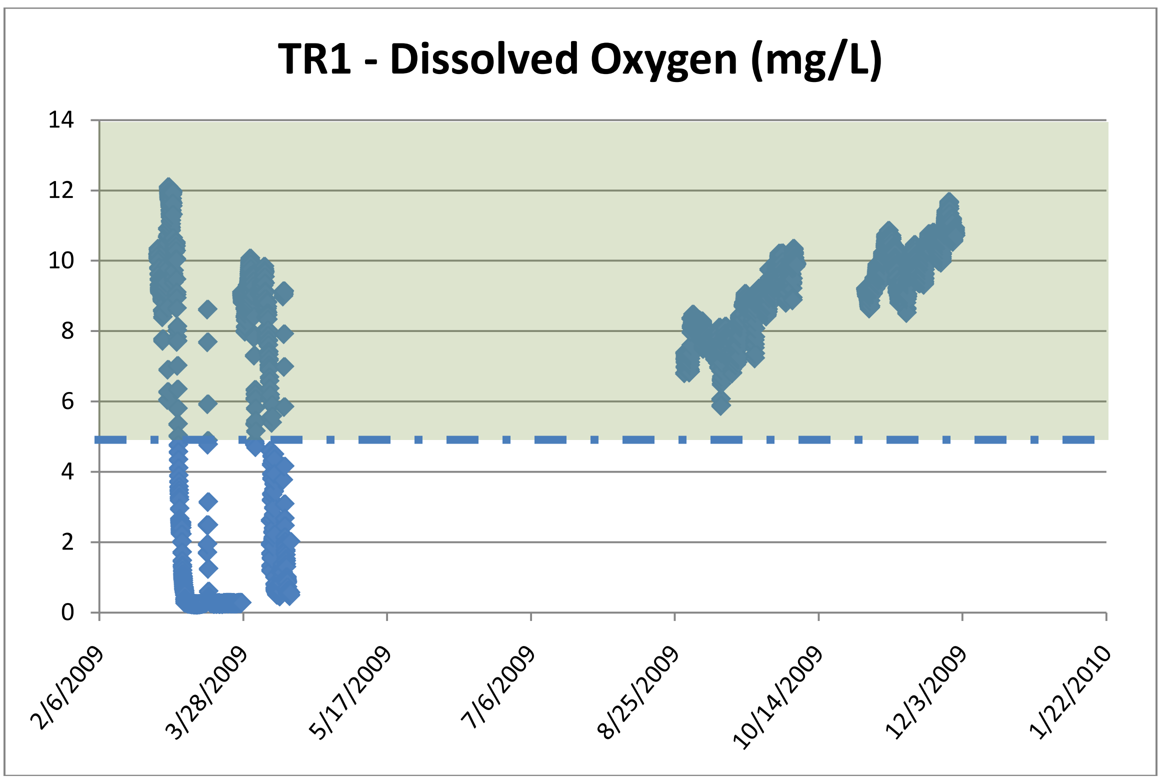
II.2 – Wet Weather Sampling Using ISCO Samplers
No Wet Weather Samplers were deployed in the West Fork of Trail Creek.

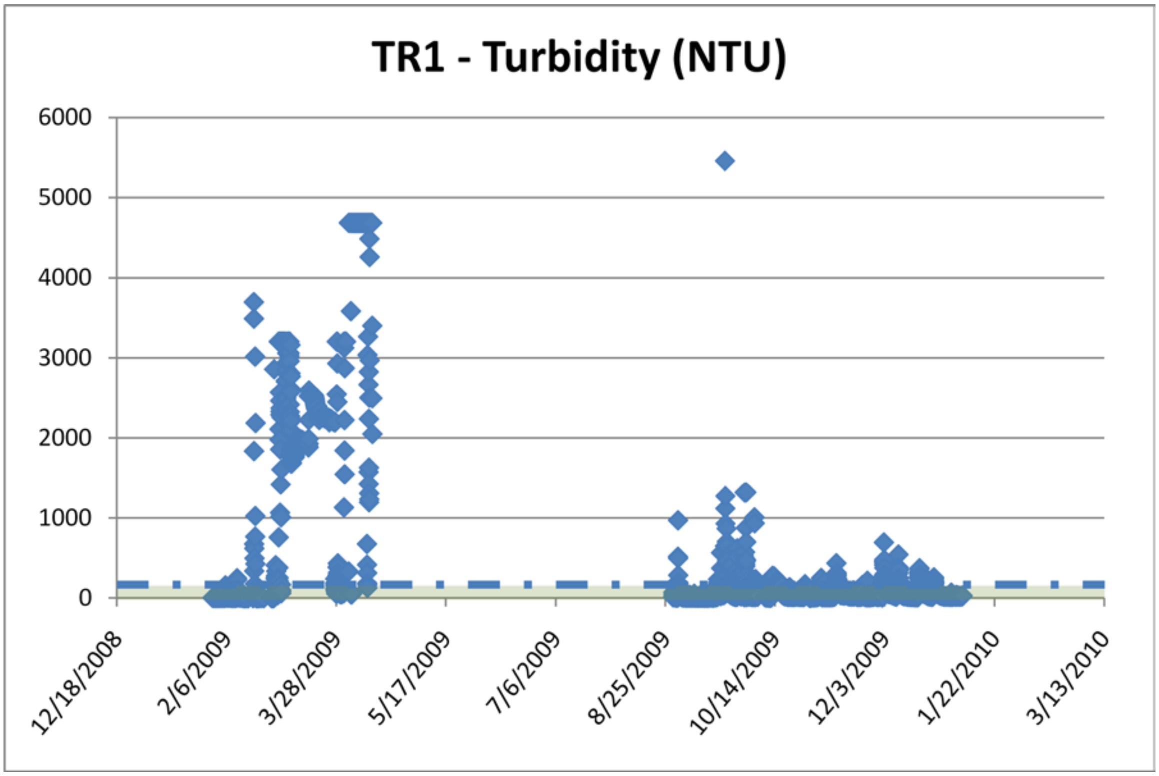
II.3 In-Situ Water Sampling Using Datasondes
Gaps in data are due to equipment malfunction and subsequent repair times.

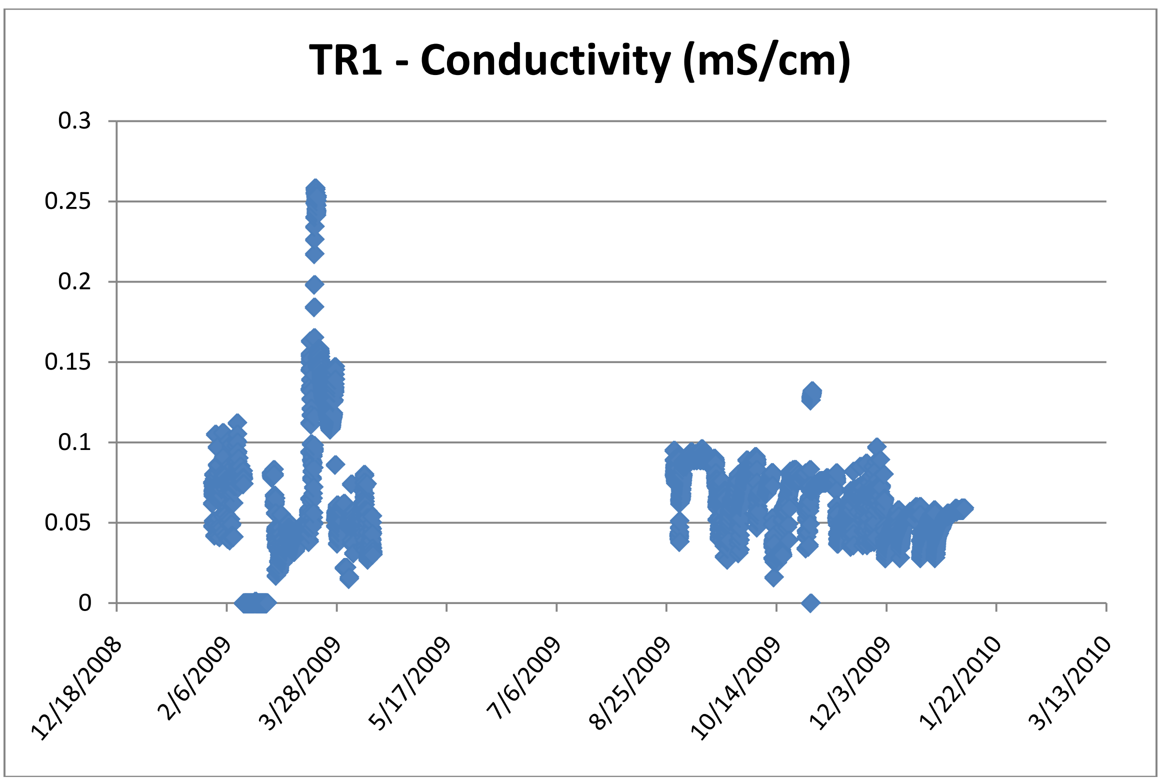
Datasonde Sample Site TR1



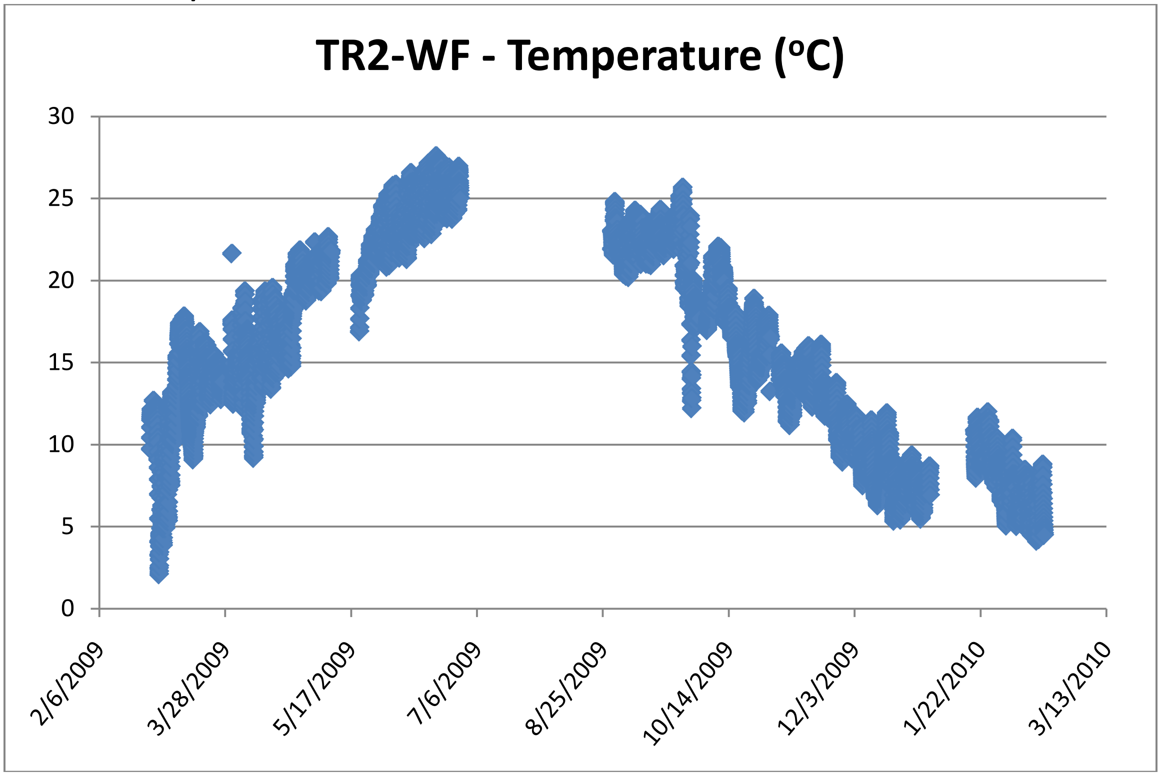

TR1 - pH
16
14
12
10
8
6
4
2
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

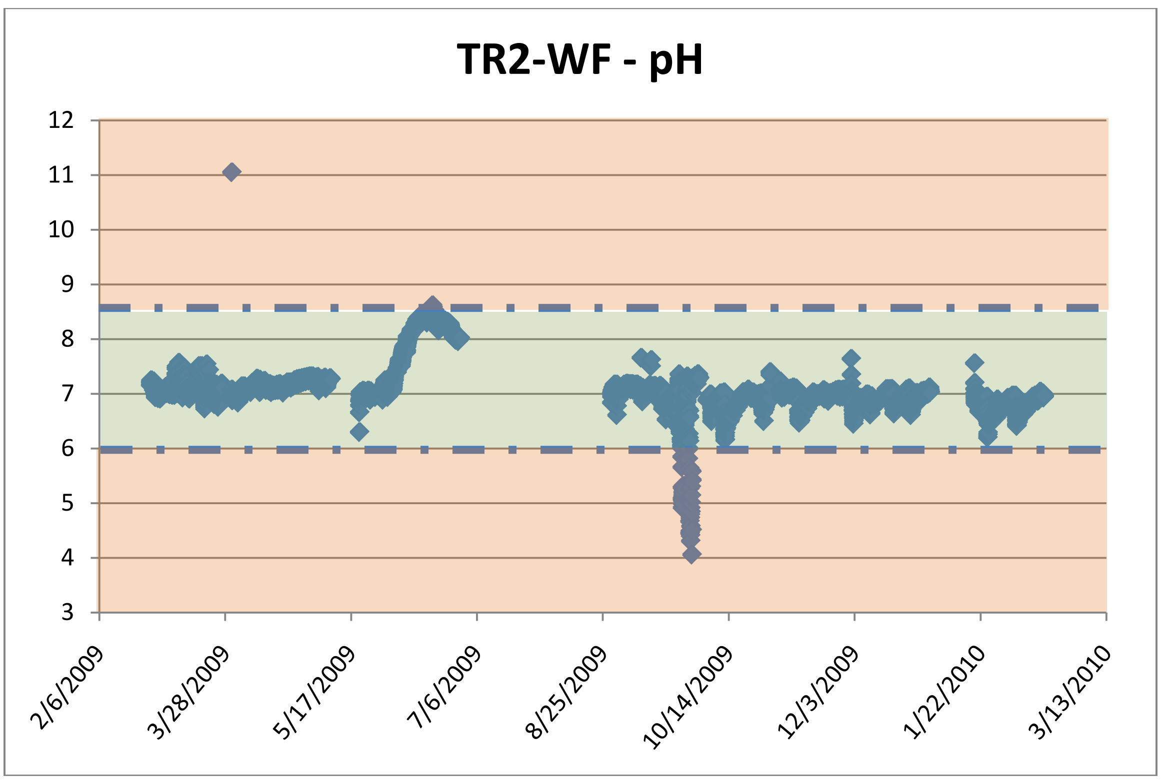

TR1 - Dissolved Oxygen (mg/L)
14
12
10
8
6
4
2
0
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010

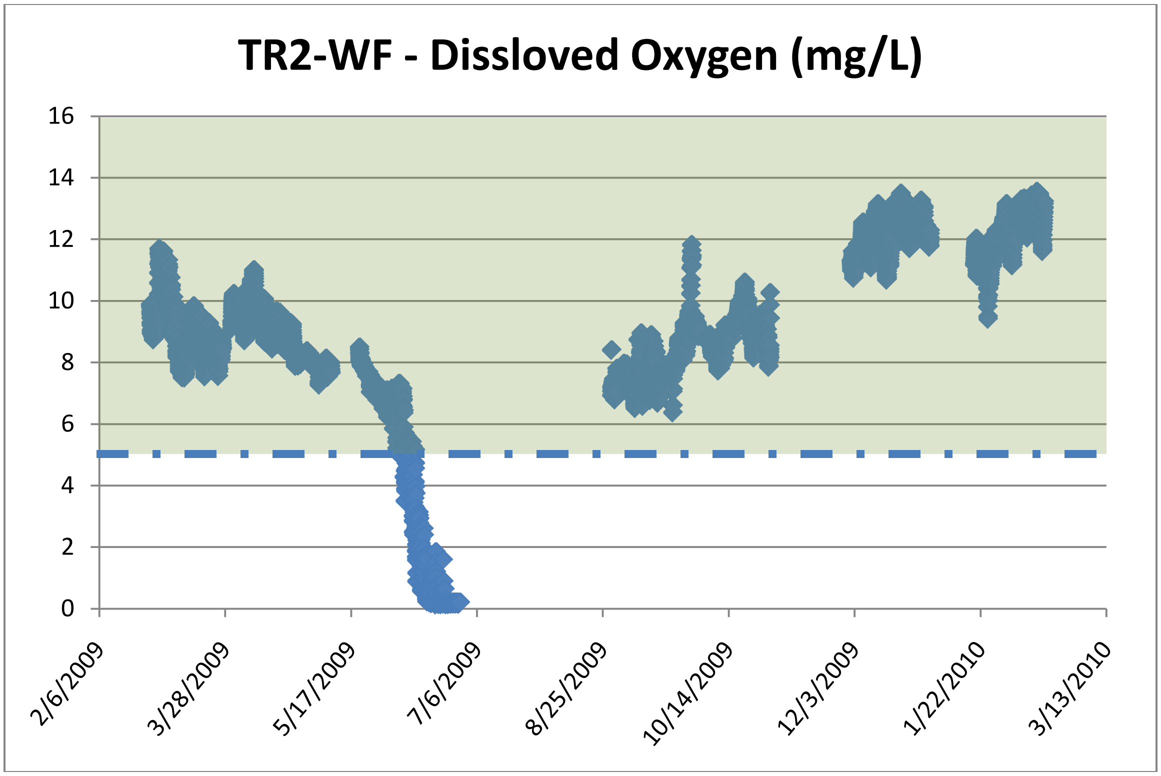

TR1 - Turbidity (NTU)
6000
5000
4000
3000
2000
1000
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

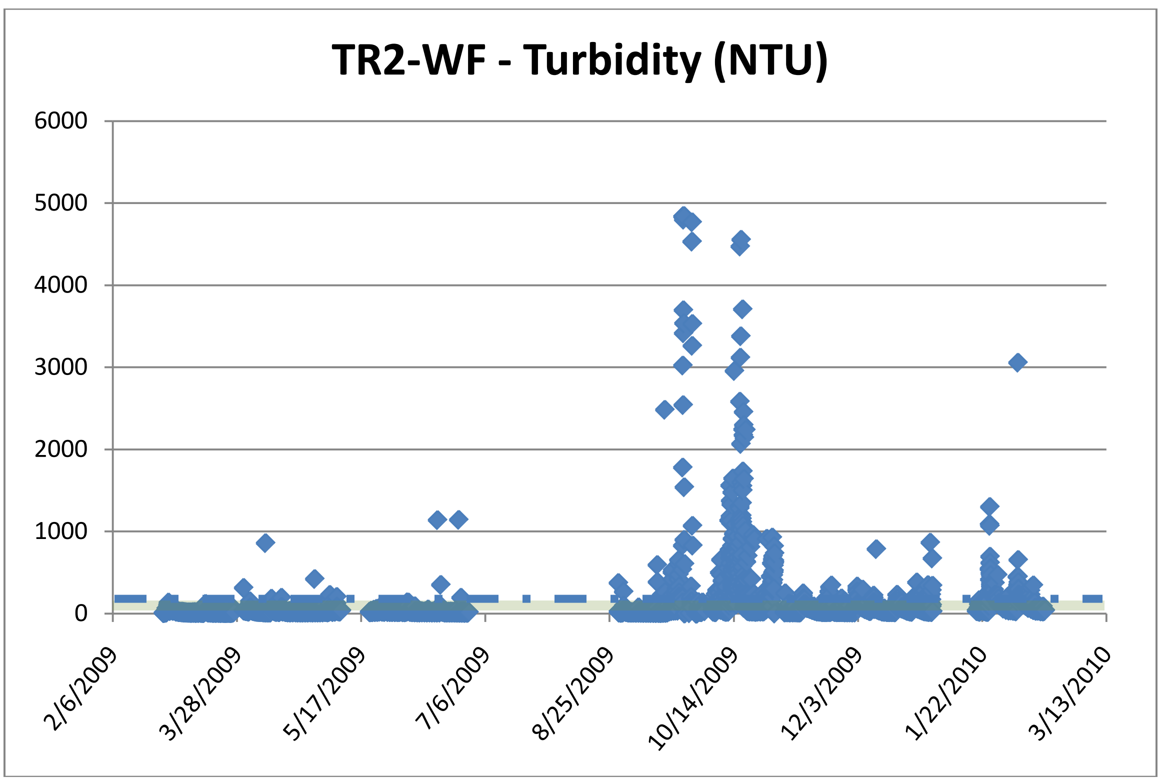

TR1 - Conductivity (mS/cm)
0.3
0.25
0.2
0.15
0.1
0.05
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

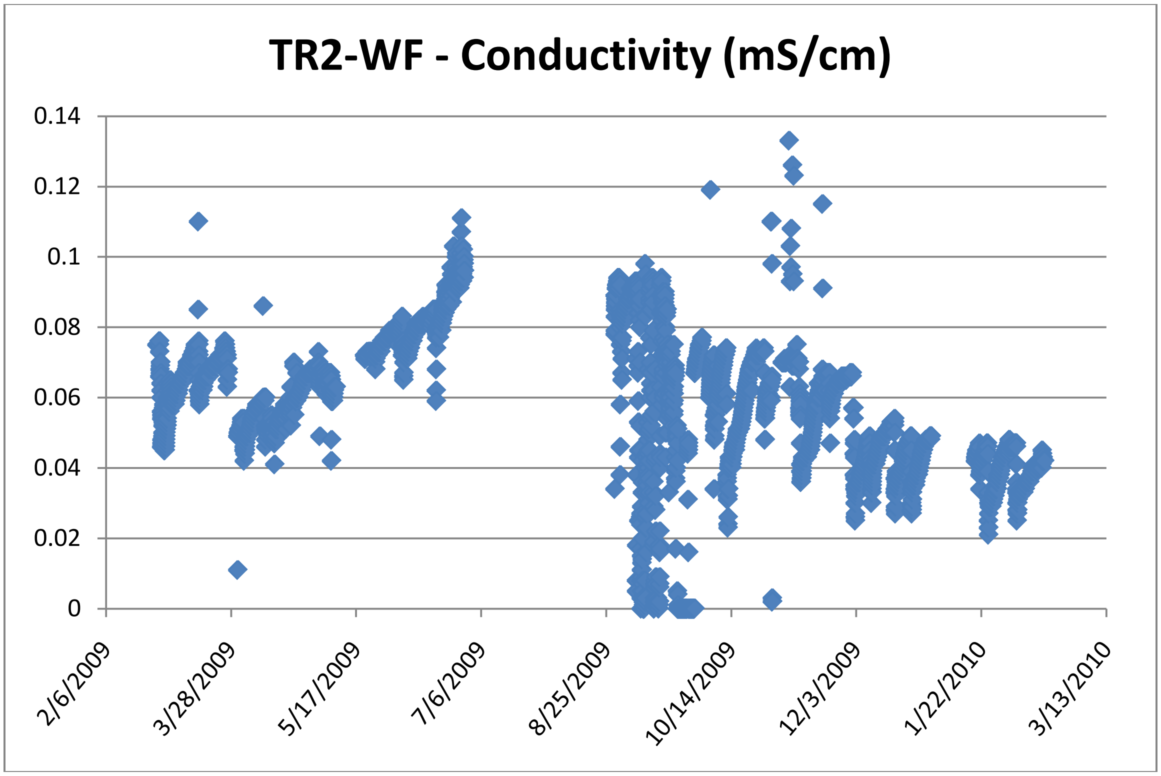
Datasonde Sample Site TR2-WF



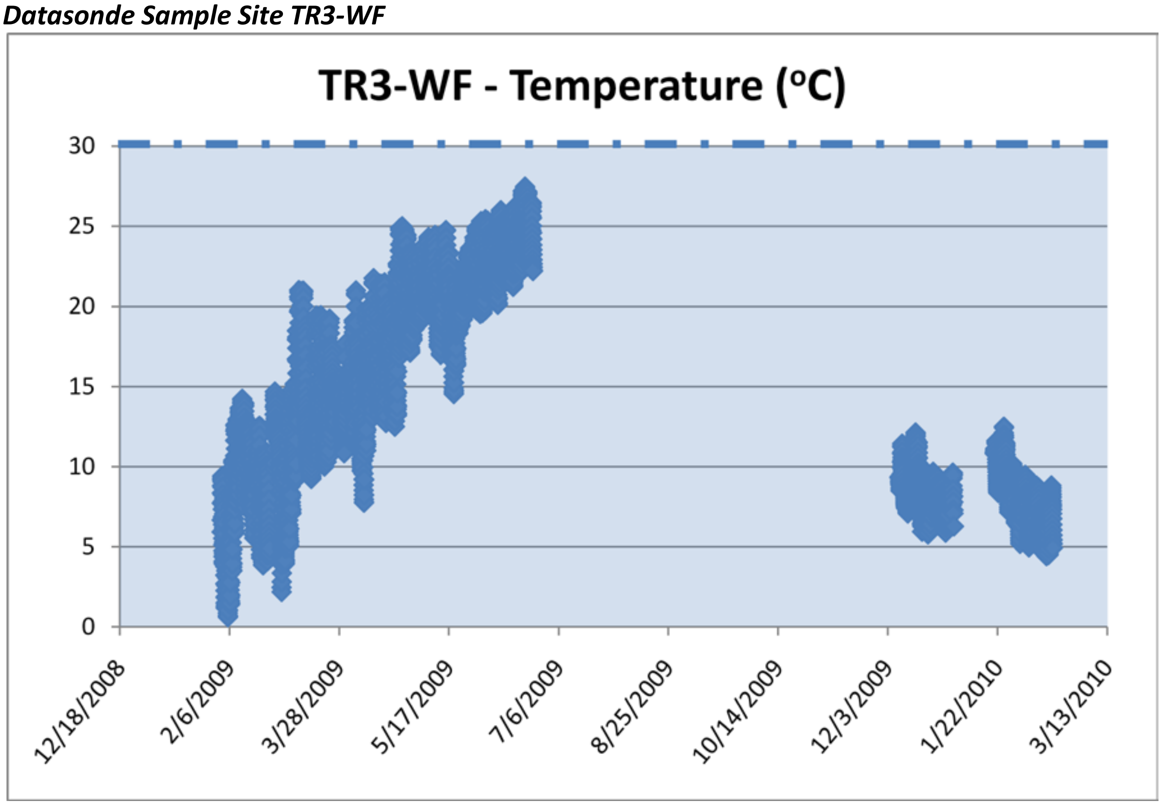


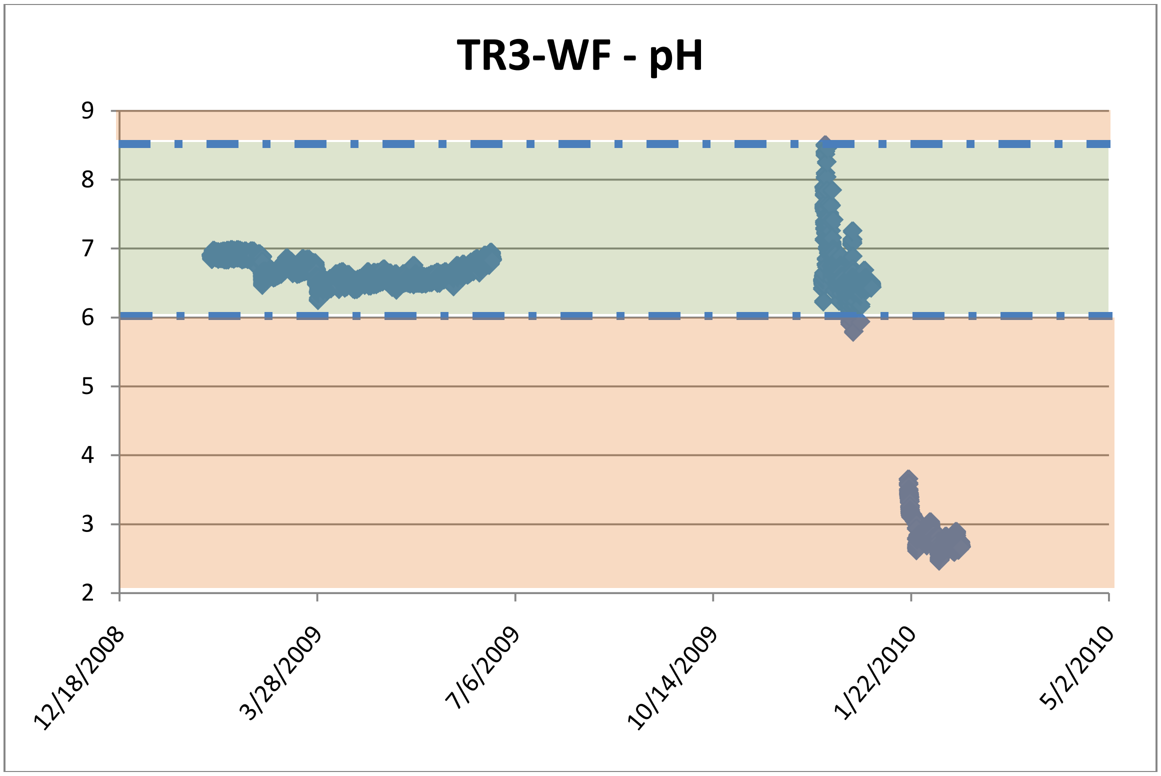

TR2-WF - Dissloved Oxygen (mg/L)
16
14
12
10
8
6
4
2
0
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

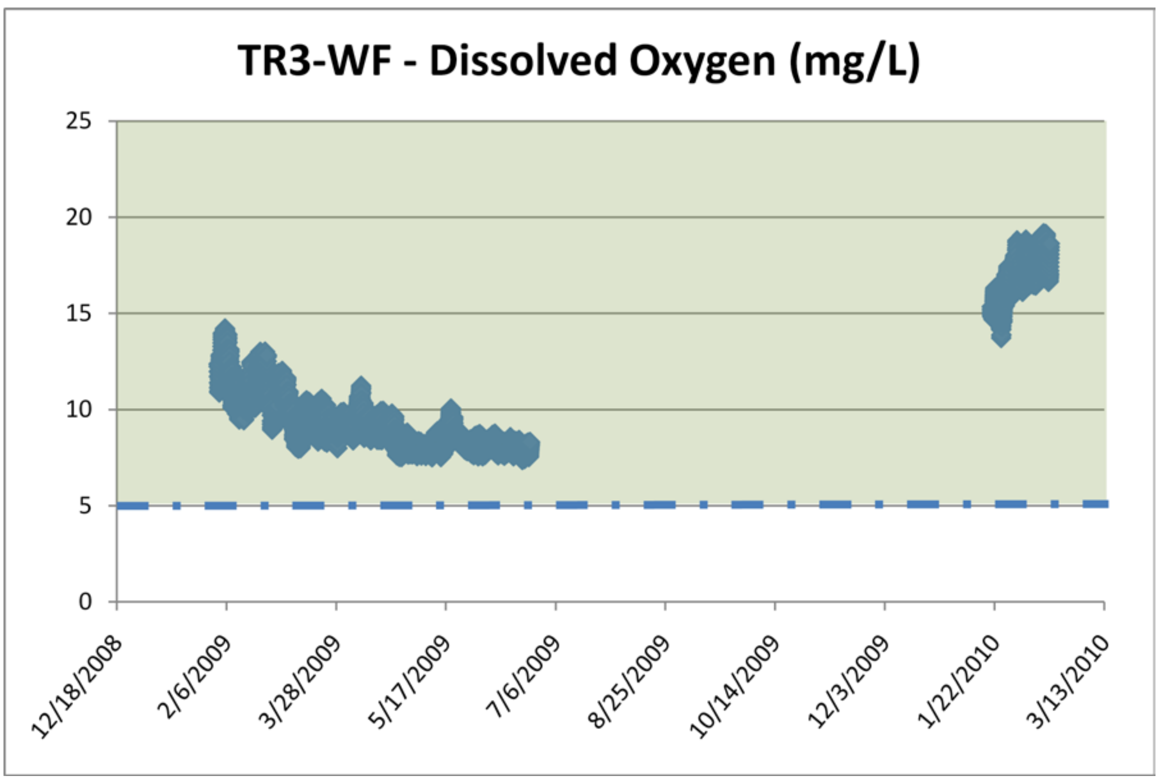

TR2-WF - Turbidity (NTU)
6000
5000
4000
3000
2000
1000
0
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

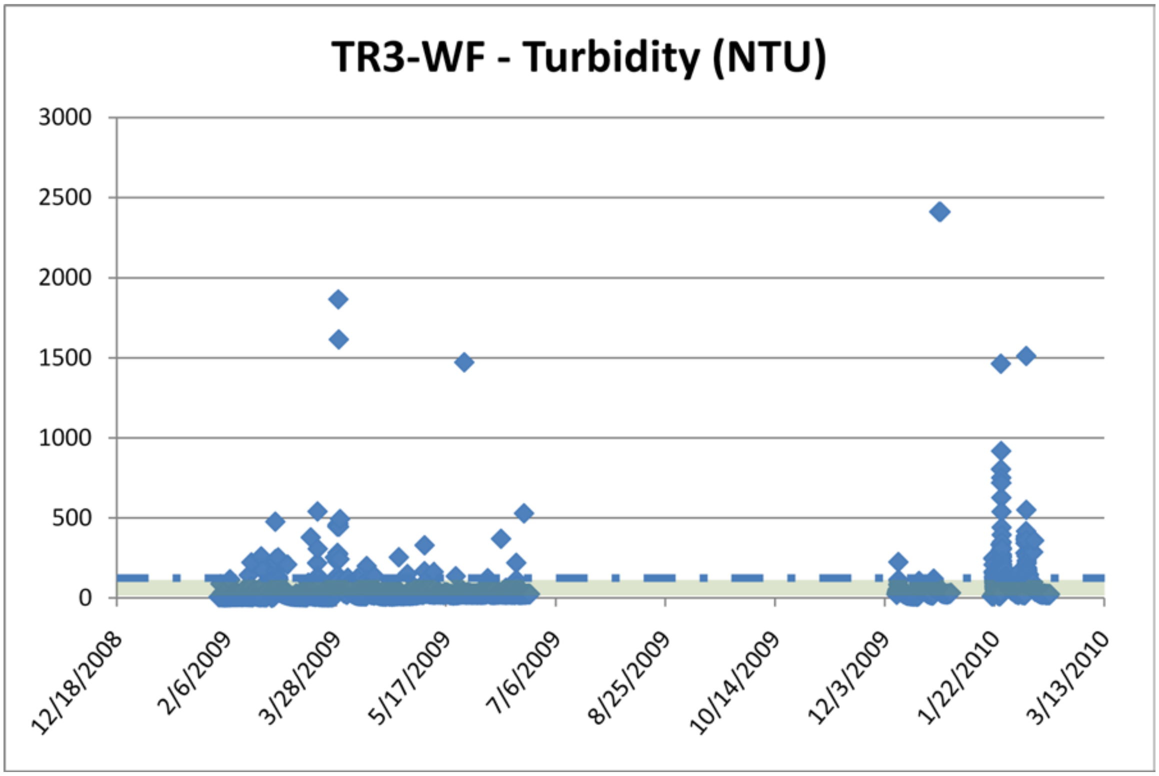


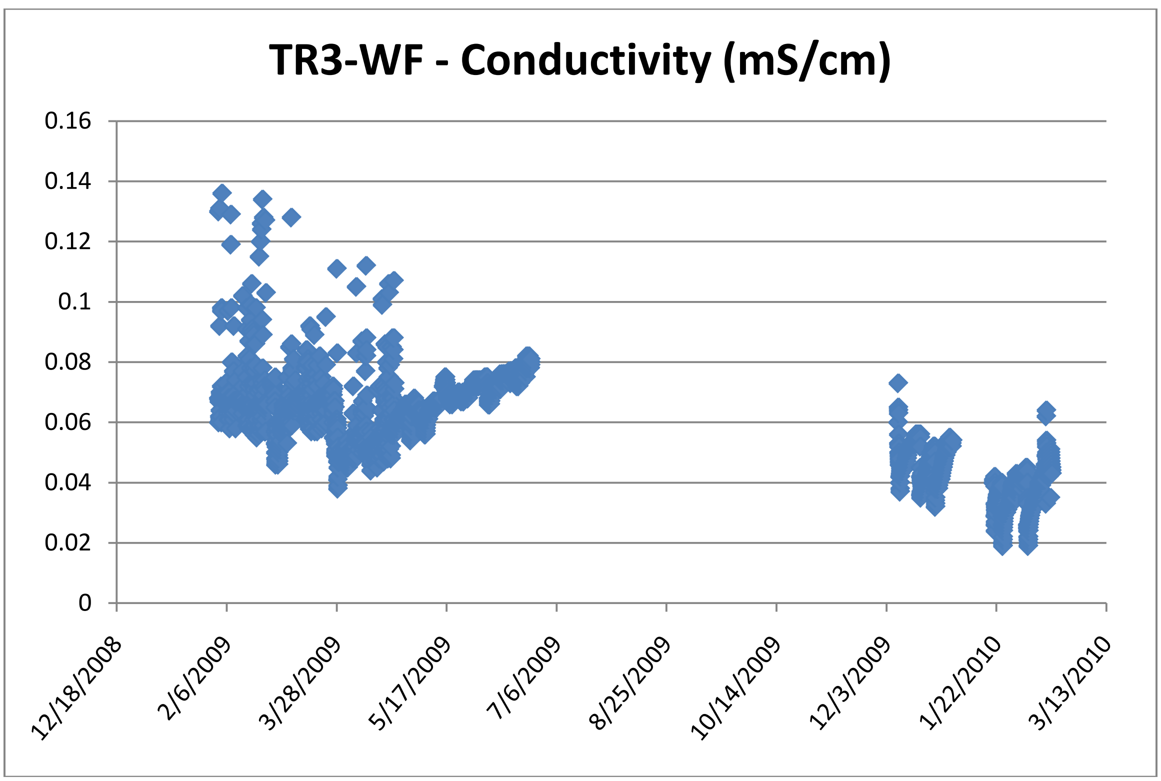
Datasonde Sample Site TR3-WF




TR3-WF - pH
9
8
7
6
5
4
3
2
12/18/2008
3/28/2009
7/6/2009
10/14/2009
1/22/2010
5/2/2010


TR3-WF - Dissolved Oxygen (mg/L)
25
20
15
10
5
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010


TR3-WF - Turbidity (NTU)
3000
2500
2000
1500
1000
500
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010


TR3-WF - Conductivity (mS/cm)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010

Section III – Baseline Indicators (as of December 2009)

Land Cover Data for TrailCreek Basin					
Column1	**Column2**	**100ft Buffer**	**Column3**	**All of Basin**	**Column4**
Type of Cover	GRIDCODE	Area (ft^2)	%	Area (ft^2)	%
Open Water	11	813168.13	2.72%	2415888.46	0.69%
Developed Open Space	21	3048843.18	10.20%	59842060.17	17.08%
Developed-Low Intersity	22	1355775.81	4.53%	50458129.52	14.40%
Developed-Medium Intensity	23	206338.18	0.69%	17246627.58	4.92%
Developed-High Intensity	24	74698.15	0.00%	6809412.23	1.94%
Barren	31	0.00	0.00%	332947.97	0.10%
Agriculture-Pasture and Hay	81	1681356.81	5.62%	43642677.56	12.46%
Agriculture-Cultivated Crops and Irrigated Crops	82	0.00	0.00%	1375426.89	0.39%
Southern Piedmont Mesic Forest	2316	1623976.88	5.43%	7493799.76	2.14%
Southern Piedmont Dry Oak (Pine)	2368	7383254.31	24.69%	78285013.35	22.35%
Central Interior and Appalachian Riparian Systems	2472	6371052.53	21.31%	11243243.01	3.21%
Ruderal Forest-Southeast Hardwood and Conifer	2533	6859714.61	22.94%	47943747.07	13.69%
Managed Tree Plantation-Southeast Conifer and Hardwood	2535	482377.32	1.61%	23239506.76	6.63%
Totals		29900555.92		350328480.32	

Trail Watershed Information		
Indicator	**Total**	**Column1**
Residential Building in Flood Hazard Zones	7	% of Total Structures = 0.12%
Non-Residential Buildings in Flood Hazard Zones	13	% of Total Structures = 0.24%
Length on Channelized/Piped Streams	1700ft	% of Total Stream = 2.6%
Impervious surface	13.60%	
of Outfalls	144	11.43/mile of stream
Septic Tanks	379	30.10/mile of stream
Sewer Crossings	10	0.79/mile of stream
Culverts	3	0.23/mile of stream
Sewer Spills	13	1997-2001: 10
		2002-2006: 2
		2006-2009: 1

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